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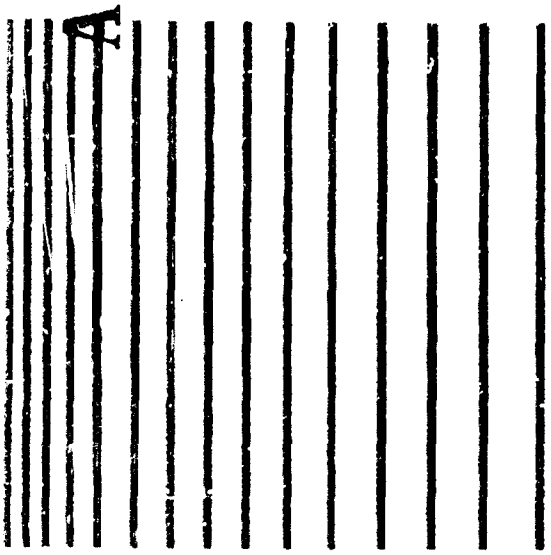

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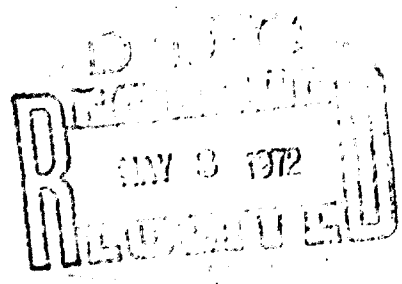

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THE SHOCK AND VIBRATION DIGEST

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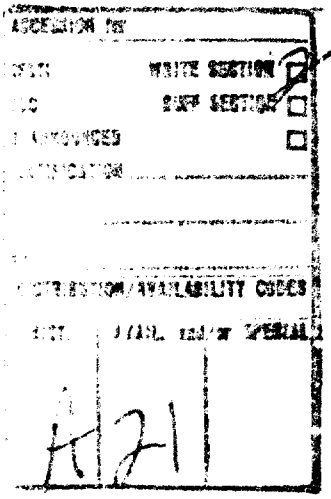

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EDITORS RATTLE SPACE

SHOCK AND VIBRATION TESTING

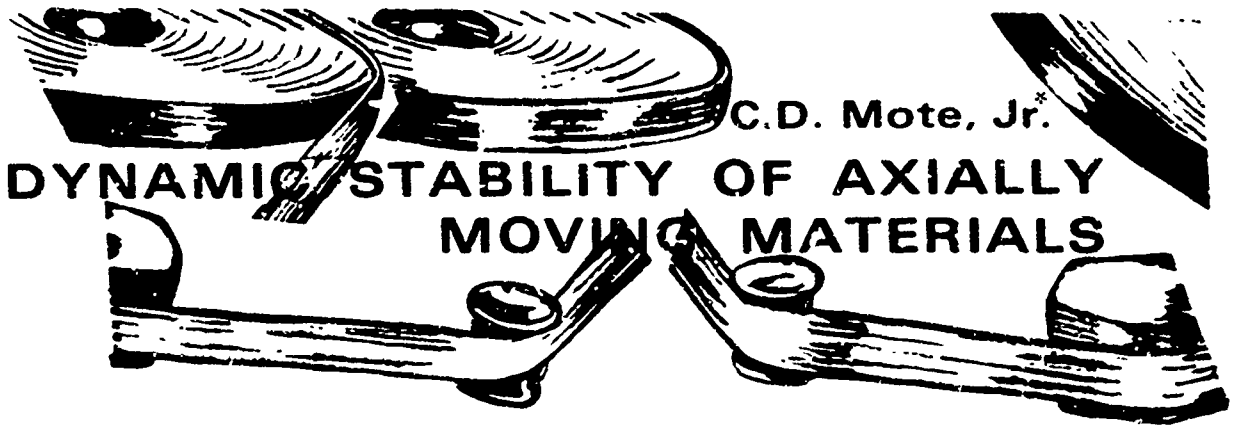
The appearance of a new monograph on "Selection and Performance of Vibration Tests" by Curtis, Tinling and Abstein published by the Shock and Vibration Information Center proves that there is some hope for the experimentalist. Shock and vibration technologists associated with structures, machines and vehicles have had little in the way of published literature for guidance in their work. From this fact, one might draw the conclusion that either there is not much shock and vibration testing activity or that little of this work is published. My feeling is that the latter conclusion is the valid one.

My experience in the shock and vibration field was gained by conducting mathematical analyses tempered by experimental verification studies. And, in all candor, I must say there are many advantages in paper studies. However, paper studies must be made on models of systems that adequately characterize the phenomena that govern the dynamic behavior of the system. This is where I think too much analysis and too little testing occurs -- where elaborate analyses are conducted on systems not well characterized. Economics is probably the outstanding reason for this abuse.

Looking at the published literature one finds few books on experimentation as opposed to the steady flow of mathematically oriented books to the market place. In addition, the literature on testing is not threatening to overflow libraries as is mathematical work. With the exception of the Shock and Vibration Bulletin and the Journal of the Society of Experimental Stress Analysis (SESA), the opportunity for publication of quality experimental work does not exist. Since the major experimental work of the SESA is not of interest to the average shock and vibration engineer, this leaves the Shock and Vibration Bulletin as the sole source of information on testing techniques, procedures, equipment and facilities. In fact, some societies look on experimental work as being inelegant (in contrast to the sophisticated mathematical vocabulary of analytical investigation) and discriminate against the publication of it.

Why do we have this situation? Analytical investigators seem to be more aggressive than experimentalists and are aided in their domination by the fact that experimental investigations are costly. I believe that there is a genuine need for experimental characterization of basic phenomena, for instance, damping. Many shock and vibration studies are devoted to calculation of the responses of damped systems without a good damping model. We need more experimental verification studies of response analyses instead of repeated new computer models predicting the behavior of systems using models with questionable phenomenological foundations.

R. L. E.



C.D. Mote, Jr.*

DYNAMIC STABILITY OF AXIALLY MOVING MATERIALS

1. INTRODUCTION

Axially moving material problems consider the lateral response, vibration or stability of long, slender members in which mass is continuously transported. Examples of such systems are magnetic and paper tapes (Ref. 38), moving bands and belts (Refs. 14, 18 and 62), chain drives (Refs. 36 and 37) moving strings (Ref. 4), textile and fiberglass fibers (Refs. 16, 23 and 25), bandsaws (Ref. 43), pipes containing flowing fluids (Refs. 5, 17 and 28), hydroelectric power plant conduits (Ref. 53), oil lines (Refs. 5, 19 and 28), and fuel lines (Refs. 21 and 32). In order to reduce the scope of our attention the following problems in this classification are excluded: (1) response of systems to inertialess moving loads; (2) response of systems to moving discrete mass (e.g., bridge response problems; and (3) response of systems under moving external mass (e.g., air foils or reactor fuel rods).

The axially moving material lateral vibration and stability problems listed herein are analogous as a first approximation, because the linearized equation of motion and boundary conditions are identical. Since the problem classification was initiated in 1897 by Rudolf Skutch (Ref. 63), considerable effort has been directed toward the incorporation of the moving mass into the analysis of the system response. Research progressed independently in the diverse technologies and only recently has the extent of the duplication of effort become better recognized. Accordingly, the discussion herein centers on major contributions and the references most pertinent to those contributions. The objectives are to review the principal developments, to provide a reasonably complete reference list and to provide some food for thought regarding directions for extensions of present developments. This latter objective is unavoidably subjective, and the writer's experience guides his remarks.

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2. GENERAL LINEAR ANALYSES

Linear, planar vibration and stability problems in straight, axially moving materials have been thoroughly studied analytically. The free, linear, undamped equation of planar motion is,

$$a_1 v_{tt} + a_2 v_{xt} + a_3 v_{xx} + a_4 v_{xxxx} + a_5 v = 0 \quad (1)$$

where the coefficients are

Coefficients	System Type	
	Strip	Pipe
a_1	m_s	$m_c + m_f$
a_2	$2m_s c$	$2m_f c$
a_3	$m_s c^2 - R(c,t)$	$\frac{A}{A_o} m_f c^2 - P(c,t) + pA$
a_4	EI	EI
a_5	0	k

and the symbols represent

A_o = nozzle area

A = pipe area

c = axial transport velocity

EI = flexural stiffness

k = foundation modulus

m_c, m_f, m_s = mass unit length (cylinder, fluid, strip)

p = pressure

R = tension

$v_{xt} = \frac{\partial^2 v}{\partial x \partial t}$; subscript denotes partial differentiation with respect to that variable.

Boundary conditions include

clamped-clamped	$v=v_x=0$	$x=0,\ell$
pinned-pinned	$v=v_{xx}=0$	$x=0,\ell$
clamped-free	$v=v_x=0$	$=0$
	$v_{xx}=v_{xxx}=0$	$x=\ell$
clamped-pinned	$v=v_x=0$	$x=0$
	$v=v_{xx}=0$	$x=\ell$

Physically, the terms in Eq. (1) arise from inertia, tension, stiffness, and an elastic foundation. The inertia loading for the strip is given by $m_s v_{tt} + 2m_s c v_{xt} + m_s c^2 v_{xx}$. Here the local transverse acceleration, the coriolis acceleration resulting from material moving axially at a velocity c and rotating at v_{xt}, and the normal acceleration of the mass moving according to the strip curvature v_{xx} are each represented. Modification of m_s for the pipe includes contributions due to internal pressure and an end nozzle, which will be discussed later. The tension, stiffness, and foundation terms in Eq. (1) are classical. The pinned-pinned boundary condition is notably approximate for systems with flexural stiffness because the boundary coupling of the system with the surroundings, at least at the upstream end, does not permit a vanishing curvature at the boundary.

The equation of motion Eq. (1) has been derived on numerous occasions from both the Newtonian and analytical mechanics formulations and the linear treatments are extensive. The systems have been infinite (Refs. 39 and 57), finite, damped, and undamped. The systems studied have been free, driven at one end (Ref. 61), driven at both ends (Ref. 38), and driven in the middle (Ref. 3). The pipe pressure has been included (Ref. 51), neglected, and varied (Ref. 57). The longitudinal tension has been treated as constant, transport velocity dependent (Ref. 43) and time dependent (Refs. 44 and 45). The transport velocity c, which is usually constant, has been varied in two cursory analyses (Refs. 33 and 38). An elastic foundation has been included in pipe problems (Refs. 57 and 65), a periodic transverse load has been included in belts (Ref. 30), and studies on uniformly curved pipe problems have recently been published (Refs. 13 and 71).

The results most often sought are the relationship between the system natural frequencies and the mass transport velocity, and the critical transport velocity above which either static or dynamic instability occurs. Exact resonance solutions have been obtained from the characteristic equation and boundary conditions using classical techniques (Refs. 43, 52 and 53); that is, let $v=V_0 \exp(ax+bt)$. Substitute v into Eq. (1) and determine a and b by requiring periodic solutions and boundary condition satisfaction. Alternative solutions of the equations of motion have been obtained by the method of characteristics (Ref. 57), by a superposition of D'Alembert traveling wave solutions (Ref. 51), by a Fourier series expansion (Ref. 14), by the Galerkin method (Ref. 43), by perturbation methods (Ref. 24) and by a power series expansion (Ref. 35). System stability as a function of transport velocity has also been the objective of a number of studies. In systems with vanishing end displacement boundary conditions, a critical transport velocity c_{crit} exists; supercritical transport velocities result in static buckling or divergence instability of the pipe or band system. Dynamic instability or flutter is not possible in end supported systems. In the continuous cantilever pipe a follower force occurs and a critical transport velocity exists for dynamic instability or flutter; divergence instability is not possible here. Note that c_{crit} (flutter) $< c_{crit}$ (divergence) so that divergence instability can be induced by the boundary constraint (Ref. 33). In articulated cantilever pipes both static and dynamic instabilities are possible (Ref. 54).

In an excellent, highly recommended paper R.A. Sack (Ref. 61) presents fundamental results for the moving string, being driven at one end,

in a concise and lucid manner. For an excitation frequency ω, he obtains,

$$v = V_0 \frac{\sin(\omega x/c')}{\sin(\omega L/c')} \cos\left[\omega\left(t - \frac{L-x}{v'}\right)\right] \qquad (2)$$

$$c' = (R - m_g c^2)/(R m_g)^{\frac{1}{2}} = \text{mean effective wave velocity} \qquad (3)$$

$$v' = (R/m_g c) - c = \text{phase propagation velocity} \qquad (4)$$

These results identify the salient features of axially moving material response: (1) resonance occurs when $\omega = n(\pi c'/L)$ where n is a positive integer; (2) the mean effective wave velocity is the mean of the upstream and downstream d'Alembert waves; and (3) the phase is not constant and propagates upstream at velocity v'.

Niordson (Ref. 53) discusses the vibration of the analogous cylindrical shell, string, and beam with both internal and external mass transport. It is one of two shell analyses (the other is by Mizoguchi, Ref. 39) and it presents a detailed discussion of the exact solution. This paper and one by Housner (Ref. 28) form the cornerstone of pipe vibration analyses. The Housner paper and an independent paper by Feodos'yev (Ref. 19) were written to correct an inertia formulation error by Ashley and Haviland (Ref. 5) in the first of the modern treatments of these problems. Long (Refs. 34 and 35) used a power series expansion technique and experiments to verify the Housner developments for low transport velocities. Agreement was good. Dodds and Runyan (Ref. 17) also conducted experiments which examined the critical transport velocity for instability and the transport velocity-frequency relationship; their results support the theoretical studies. Principal developments in the analogous band problems are given by Chubachi (Refs. 14 and 15), where the exact solution and a Fourier series approximate solution are given for a one-dimensional band, and by Mote (Ref. 43) and Mote and Naguleswaran (Ref. 41), where the exact solution, a Galerkin solution and a modified Southwell solution are presented. The latter approximate solution is particularly useful for it permits accurate, approximate spectral analysis in systems with nonzero flexural stiffness without numerical computation (also see Ref. 18). Experiments support the theory generally but are limited to relatively low transport velocities.

The mechanical energy of the axially moving material system has been the subject of some research interest (Refs. 7, 14, 38, 48 and 52). The total mechanical energy is never constant for $c \neq 0$ in the cantilever pipe discussed by Nemat-Nasser, et al (Ref. 52), which is a follower-force problem, energy is not conserved. However, even if the system is end-supported to eliminate the follower-force work contribution, there is a continual, periodic transfer of energy into and out of the system for a periodic response. Chubachi (Ref. 14) and Miranker (Ref. 38) discuss the periodicity of the energy transfer (at twice the response frequency) and show that the response amplitude for $c \neq 0$ can be much larger than with $c = 0$ for the same initial conditions. One can say that "mean" energy is constant for periodic response with simply supported or clamped boundary conditions. Variational methods have been used frequently to formulate the equations of motion (Refs. 1, 4, 8, 26, 30, 38, 42, 48, 51, 57, 64 and 71). For the most part, the conservative Hamilton's Principle,

$$\int_{t_1}^{t_2} (T - V)\, dt = 0, \qquad (5)$$

is used where T and V are the kinetic and potential energies of the system between its ends, which are supported, and where t_1 and t_2 are fixed limits. As the correct equation of motion is obtained as the Euler equation in Eq. (5), it is a meaningful variational problem. However, Benjamin (Ref. 8) points out that this is an incorrect application of Hamilton's Principle. In Hamilton's Principle one must take stock of all mass particles of this variable mass system: the steady state system has infinite energy. Benjamin discusses the adaptation of the Lagrangian method to infinite energy systems. The Lagrangian equations are found in terms of energies of the finite part of the overall system with careful attention given the kinetic energy flow into and out of the section.

Oscillation of pipes with attached discrete masses has been investigated by Roth (Refs. 58 and 60), who examined a cantilever pipe with end mass in the boundary conditions, and by Hill and Swanson (Ref. 27), who included concentrated mass using a Dirac distribution function.

Parametric excitation, resulting from harmonic tension variation, has been studied to incorporate the axially moving mass into stability predictions (Refs. 18, 30, 36, 43, 44, 45, 50, 56 and 57). Periodic tension variation may result from pulley eccentricities in bands and support

excitation in pipes. Doyle and Hornung (Ref. 18) in an experimental study on V-belt vibrations demonstrate excitation by pulley eccentricities and by belt stiffness variations. Naguleswaran and Williams (Ref. 50) used experiments and a Galerkin solution to formulate a coupled, Mathieu equation sequence. The principal instability occurs when the parametric frequency is twice the fundamental frequency as expected. This parametric instability was more severe than the classical resonance which occurs when the pulley rotation frequency equals the fundamental. Theoretical developments predict instability conditions, but they require an accurate knowledge of the system tension (Refs. 18 and 50). Ignorance of the system tension under transport conditions notably restricts implementation of the theoretical analyses in addition to complicating experimental studies. Mote (Ref. 44) examined the parametric instability in coupled bending-torsion in axially moving bands. The theoretical results were supported by numerical integration of the differential-difference equations of motion (Ref. 45). Rhodes (Ref. 56) investigated an interesting parametric excitation problem in belts where tension variations are stored on the pulleys, because of belt-pulley friction, and then later "played" back into the system as the belt leaves the pulley.

Static or divergence buckling is discussed in Refs. 21, 46, 66 and 68). Application of these analyses is directed toward the edge-load bifurcation instability of bands, although they apply equally to the analogous pipe problems. The buckling load decreases as the square of the transport velocity until the critical velocity is reached. At the critical velocity, bifurcation occurs for any load; for example, in Eq. (2) with n=1 the divergence critical velocity becomes.

$$\lim \lambda \to 0$$

$$c \to c_{crit}$$

$$c_{crit} = \left(\frac{F}{m_s}\right)^{\frac{1}{2}} \qquad (6)$$

An interesting discussion of critical velocities based upon the Lyapunov method is given by Movchan (Ref. 49).

Nonconservative, follower force, stability problems in cantilever pipes have been examined in Refs. 8, 11, 12, 22, 48, 52 and 54. Nemat-Nasser, et al (Ref. 52) used classical methods and more recently, Mote (Ref. 48) used the finite element method. In a letter, Chen (Ref. 11) formulates the eigenvalue problem and the adjoint eigenvalue problem with zero coriolis acceleration ($\alpha_2 \equiv 0$ in Eq. (1)) and presents a classical principal coordinate solution. However, coriolis contributions do not appear to be generally negligible. Recently, Chen (Ref. 12) theoretically examined a pipe clamped at one end and elastically supported at the other. The character of the instability is controlled by the elastic boundary coefficient, and static to dynamic instability region transitions occur with increasing transport velocity. Benjamin (Ref. 8) concentrated his effort on cantilever, articulated pipes. He found that his cantilever pipe motion was independent of fluid friction. His experimental observation and heuristic argument is supported by Gregory and Paidoussis (Ref. 22), where cantilever stability is examined both theoretically and experimentally, and recently by Liu (Ref. 33) for moderate flow rates. In this excellent paper by Benjamin, derivation of the equations of motion is given careful treatment, and experiments generally support theoretical findings.

The influence of pipe pressure upon the system response is interesting, important and somewhat unclear in the literature. The majority of research papers do not explicitly include p (e.g., see α_3) in the formulation while a number do include it (Refs. 10, 26, 51, 57 and 65). In order to clarify the situation, the equations of motion of the transport mass and the pipe are examined separately; see Fig. 1.

Assuming Euler-Bernoulli beam theory, transverse displacement, and the usual linearization approximations, we obtain the equation of transverse motion and longitudinal equilibrium

$$-(EIv_{xx})_{xx} + \left[(R-pA)v_x\right]_x$$
$$= m_f(v_{tt} + 2cv_{xt} + c^2v_{xx}) + m_c v_{tt} \qquad (7)$$

$$(R - pA)_x = 0 \qquad (8)$$

Friction existing between the transport mass and the pipe enters the analysis through the tension R. It is important to note that R is the total tension resulting from the applied axial load, friction, thermal effects, constraint of Poisson axial contraction resulting from internal pressure, etc. From Eq. (8) we see that R and pA differ by a constant (say C_o);

$$R - pA = C_o \qquad (9)$$

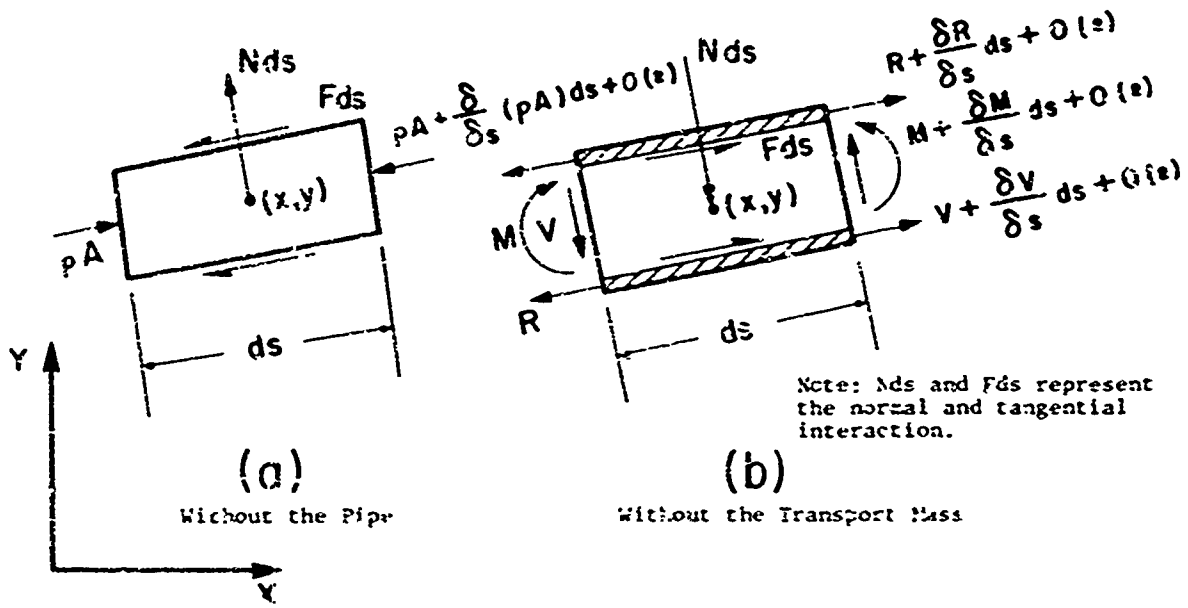

Fig. 1 External Forces Acting upon the Transport Mass

A number of interesting physical situations arise. First, for a uniform, free end, cantilever pipe or an axially unconstrained, uniform free end pipe, both R and pA vanish at the free end and $C_0 = 0$ in Eq. (9). Returning to Eq. (7), we see that the response is not explicitly a function of pressure or friction as noted by Benjamin (Ref. 8), and later discussed by Gregory and Paidoussis (Ref. 22). Secondly, if frictionless transport occurs in a pipe that is not axially loaded and constrained so that zero axial load is induced by either the transport or pressurization processes, then $R \neq 0$ in Eqs. (7) and (9) becomes $-pA = C_0$ (Ref. 65). However, frictionless transport is rare at velocities of interest here. As a historical note, designers attempted in the past to stiffen cylinders to resist Euler buckling in aircraft struts and oil drill strings with pressurization. For a closed cylinder in equilibrium R=pA and $C_0=0$ in Eq. (9). Pressurization will neither affect the buckling load nor the frequency response of a closed cylinder; this was also observed in Ref. 33. In a general case $C_0 \neq 0$ in the pipe section and the axial load is a function of pressure because of pipe constraints.

The axial load R in bands is also a function of transport velocity because of the normal acceleration of band at the pulley and the pulley support compliance (Refs. 36, 41, 42, 43 and 50). The simple model gives (Ref. 43)

$$R = R_o + m_s c^2 \qquad (10)$$

$0 \leq \quad \leq 1$

R_o = static tension (c=0)

= support compliance
=0 rigid pulley support and
=1 compliant pulley support)

Ignorance of - restricts application of theoretical developments (Refs. 18 and 50). The dependence of tension upon the transport rate is a common problem for implementation of analysis in both bands and pipes.

In an interesting note Handelman (Ref. 24) examines the response of a pipe using a perturbation expansion about zero transport velocity (c=0) and zero frequency ($c=c_{crit}$). General characteristics of the natural frequency vs transport velocity relationship at these points result

from the form of the perturbation equations without requiring explicit solution. A similar development for moving bands is given in Ref. 43.

Alspaugh (Ref. 1) first studied the torsional response of an axially moving band with concentrated edge load. The paper discusses purely torsional vibration and buckling, and it emphasizes the frequency dependence upon edge load. Soler (Ref. 64) examined the thin strip under concentrated edge loading using a coupled, bending torsion analysis. Coupling can only reduce critical load predictions, and he showed that notable errors arise in some cases if it is neglected.

Articulated [illegible] were introduced as theoretical and [illegible] by the continuous system. [illegible] articulated pipes are [illegible] dynamic instability) and both (static instability) while the continuous cantilever [illegible] exhibit dynamic instability (Refs. 8, 22 and 55). Paidoussis and Deksnis (Ref. 54) recently investigated this paradox and attribute the difference to improper modeling of the higher continuous modes by the articulated model.

Experimentation in these problems is notably complex. In bands and strings, isolation of the system between end supports from the surroundings, and elimination of extraneous excitation from the splice, pulley eccentricities, etc. is quite difficult because these problems are more severe at higher transport velocities, where one is most interested in the analysis. experiments are usually performed at relatively low velocity (Refs. 18, 41, 50 and 56). In pipe experimentation the situation is somewhat better although model materials, such as rubber and nozzles, have been frequently used to reduce critical transport velocities (Refs. 22, 27, 51 and 55). Nagaleswaran (Ref. 51) has observed limitations in this procedure resulting from high pressure dilation of the model pipe, local buckling of the model, and nonlinear material behavior. Again, the response near critical transport velocities is of greatest interest where the model is least appropriate. Recent, full-scale, frequency-transport velocity experiments on clamped-clamped, and clamped-free continuous aluminum pipes have been performed by Lin (Ref. 33) in a transport velocity range exceeding critical. His results indicate that theoretical predictions in the low to moderate flow rate range are satisfactory, if appropriate coefficients a_i are used Eq. (1), and that at higher flow rates near critical the theoretical model is seriously deficient. This will be discussed in Section 4.

3. NONLINEAR ANALYSES

Although research effort has concentrated on linear problems, notable nonlinear research has been published (Refs. 2,3,6,29,31, 40, 47, 69, 70 and 72). Most of these analyses consider zero stiffness, second order systems (i.e., strings and fibers) and nonlinearities of an elementary form. Hsiang (Ref. 29) introduced a small nonlinearity first proposed by Zaiser (Ref. 72) in which Rv_{xx} in Eq. (1) is replaced by $Rv_{xx}(1-v_x^2)^{\frac{1}{2}}$. He used the method of characteristics and a [illegible] bation method to examine this correction. Mote (Ref. 40) introduced an alternative simple nonlinearity where Rv_{xx} in Eq. (1) is replaced by $Rv_{xx}-3v_{xx}v_x^2(R-AE)^{-2}$. The method of characteristics was used to compute the fundamental period, and the results indicate that the effect of tension variation during oscillation becomes increasingly significant as transport velocity increases. Bapat and Srinivasan (Ref. 6) examined both these nonlinearities by the method of harmonic balance and obtained satisfactory results.

The nonlinear moving string is examined under planar excitation by Ames, et al (Ref. 3). In this interesting paper the equations of motion are formulated with material and geometric nonlinearities included. The nonlinear string is shown to be reasonably represented by a hardening spring model. Experiments show the response to be periodic, in either a planar or a three-dimensional "ballooning" motion for planar periodic excitation. Jumps are observed from "ballooning" to second mode planar motion. They conclude that forced oscillations in axially moving strings are only analyzable by nonlinear theory.

Thurman and Mote (Refs. 47, 69 and 70) examine the free, nonlinear, planar oscillations of axially moving fourth-order systems. These systems execute longitudinal and transverse oscillations in the plane. A general approximate solution technique is developed for periodic solutions of the coupled, nonlinear differential equations of motion that results in accurate and efficient period calculations. Relative importance of nonlinearities increases as the transport velocity increases; curves are presented for estimation of linear period accuracy.

4. POSSIBLE RESEARCH DIRECTIONS

In the words of Mark Twain, "It is difficult to make predictions -- particularly about the future." Keeping this quotation in mind, the writer would like to indicate a few research problems warranting further attention. Remarks here are directed toward understanding the foundations of the subject rather than centering upon important practical problems, numerical techniques, etc.

First, out-of-plane motion or motion in the plane orthogonal to the longitudinal axis, is the norm rather than the exception. This problem has been introduced by Ames (Ref. 3) in strings and experimentally observed by Liu (Ref. 33) in pipes. They found that out-of-plane, coupled motion occurs at all transport velocities although it is particularly significant at the higher rates where the amplitude is of the same order of magnitude as the expected response. The relationship of the linear, planar analyses to the observed behavior must be clarified, and more representative theoretical models should be explored.

All research except for Miranker (Ref. 38) and Liu (Ref. 33) have constrained the transport velocity to be constant. Miranker introduced but did not develop a variable velocity analysis. In a recent experimental and theoretical study, Liu shows that a variable velocity can excite instability; deceleration of the transport mass is a destabilizing process and acceleration is a stabilizing process. All systems obviously accelerate and decelerate, and some technological examples, such as magnetic tapes, spend a notable percentage of their operation accelerating and decelerating. The problem area of the response and stability of accelerating axially moving materials is important and virtually untouched.

Research has concentrated on straight, axial systems with initial curvature neglected. As a first approximation Unny, et al (Ref. 71) examined a curved tube by invoking the Rayleigh hypothesis (inextensible pipe) and assuming that the equilibrium configuration is independent of the transport velocity. Chen (Ref. 13) indicates that numerical errors lead to incorrect stability conclusions in this paper. Moreover, observations indicate that the curved pipe is not inextensible and also that the equilibrium configuration is a function of transport velocity. Even "slightly" curved systems (those intended to be straight) execute significant deformation because of mass transport. Notable pipe tension results from the normal acceleration of the moving mass. At significant transport velocities ($c > 0.4 c_{crit}$) large initial deformation is to be expected and must be considered in the theoretical model. The importance of pipe friction in the response must be carefully reconsidered in the curved system.

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SESA SPRING MEETING

23-26 May 1972
Sheraton-Cleveland Hotel
Cleveland, Ohio

The slogan for SESA's Spring Meeting this year is "Testing Guarantees Performance"; a diversified technical program is planned consisting of papers and workshops, a manufacturer's exposition and tours of Chevrolet's Cleveland plant, local steel mills and the NASA-Lewis Research Center. Research, applications and educational sessions will cover a wide variety of subjects in the field of experimental mechanics. Topics include: buckling, fracture and fatigue, nondestructive testing, residual-stress measurements, photoelasticity, testing and transducers interferometry, composites, dynamic testing, just good applications, elastoplastic analysis, wave propagation, fatigue-life measurements and in-progress research. Four two-day workshops, for which certificates will be granted, will be given in the areas of problem solving with stress analysis, modeling, instrumentation and strain gages.

Another highlight of the 1972 Spring Meeting will be an exposition of the latest advances in techniques and products by leading manufacturers. Lively, working exhibits will be featured and highly competent representatives will be on hand to demonstrate, to explain and to answer questions on their respective exhibits.

There will also be social activities and a full program of special interest to families and other guests. The latter includes a visit to the Cleveland Museum of Art and Severance Hall.

The Spring Meeting Banquet on Thursday evening 25 May will be addressed by Abe Silverstein, director of environmental planning for the Republic Steel Corporation. He will present a critical examination of current research and development activity as a guide for the future.

A listing of sessions of interest to DIGEST readers follows. For additional details contact L. K. Savary, Society for Experimental Stress Analysis, 21 Bridge Square, Westport, Conn.

SESSION 1 — WEDNESDAY 24 MAY

BUCKLING

C. S. Barton, Chairman
Brigham Young Univ.
T. M. Brittain, Co-Chairman
Univ. Akron

An Experimental Study of the Magneto-Elastic Postbuckling Behavior of a Beam
Popelar, C.H. (Ohio State Univ.)
Bast, C.O. (H.K. Ferguson Co.)

An Experimental Buckling Study of Skin-Corrugated Ring-Stiffened Curved Panels
Tenerelli, D.J. and Holmes, A.M.C.
(Lockheed Missiles and Space Co.)

SESSION 2 — WEDNESDAY 24 MAY

FRACTURE AND FATIGUE

S. S. Manson, Chairman
NASA-Lewis Res. Ctr.
E. E. Day, Co-Chairman
Univ. Wash.

Predicting Fatigue Failures with Conducting Polymer Fatigue Damage Indicators
Daily, J.W. (Univ. Md.)
Panizza, G. (Montevideo, Uruguay)

A Fracture Mechanics Analysis of the Adhesive Failure of a Lap Shear Joint
Chang, M.D.; De Vries, K.L.; and Williams, M.L. (Univ. Utah)

Deflection of Mild Steel Beams under Symmetric Alternating Load
Krishnasamy, S. (Ontario Hydro)
Sherbourne, A. N. (Univ. Waterloo, Canada)
Khurana, K.K. (A.W. Hopeman & Sons Co.)

SESSION 13 THURSDAY 25 MAY

WAVE PROPAGATION

J. D. Chalupnik, Chairman
Univ. Wash.
E. S. Gaffney, Co-Chairman
Babcock and Wilcox

One-Dimensional Wave Pulses in Steel-Epoxy Composites
Sierakowski, R.L.; Neville, G.E., Jr.; Ross, C.A.; and Jones, E.R. (Univ. Fla.)

Torsional Impact Apparatus
Culver, R.S. (Univ. Calgary, Canada)

Elastic Wave Propagation in a Joined Cylindrical-Conical-Cylindrical Shell
Rose, J.L.; Mortimer, R.W.; and Blum, A. (Drexel Univ.)

SESSION 14 THURSDAY 25 MAY

DYNAMIC TESTING

A. F. Lawrence, Chairman
MTS Syst. Corp.
R. F. Griffin, Co-Chairman
Warner and Swasey Co.

Considerations for Instrumentation of Typical Dynamic Tests
Ives, K.D. (U.S. Steel Corp.)

Dynamic Kc Testing
Roberts, R. (Lehigh Univ.)

Shock Spectrum Test Techniques for Dynamic Evaluation of Structural Systems
Scott, J.W. (Bell Telephone Labs.)

The Application of Holography to the Visualization of Tire Vibration
Potts, G.R. (Firestone Central Res. Labs.)

SESSION 15 FRIDAY 26 MAY

IN-PROGRESS RESEARCH

R. Mark, Chairman
Princeton Univ.
R. Papirno, Co-Chairman
Army Matl. Mech. Res. Ctr.

This special session will consist of 10 min talks describing research in progress. Presentations will deal with all aspects of experimental mechanics.

SESSION 16 FRIDAY 26 MAY

FATIGUE LIFE MEASUREMENTS

E. I. Riegner, Chairman
Boeing-Vertol Div.
J. A. Hakkio, Co-Chairman
Cleveland Pneumatic

The Use of Airborne Magnetic Tape Recorders for Fatigue Life Monitoring
Peckham, C.C. (Tech., Inc.)

An Electronic Strain Level Exceedance Counter for Use in Fatigue Monitoring Programs
Phillips, E.P. (NASA-Langley Res. Ctr.)

S/N Fatigue Life Gage -- Applications Engineering
Dorsey, J. (Micro-Measure, Div.)

Electronic Readout of Scratch-Gage-Disk Information for Fatigue Studies
Baganoff, F.G. (Baganoff Assoc., Inc.)

SVIC Notes

The 43rd Shock and Vibration Symposium to be held at Asilomar, California, 5-7 December, will be hosted by the U. S. Army (at Fort Ord near Monterey). Papers are solicited on problems related to the measurement, description, simulation and means of minimizing the effects of mechanical shock or vibration on military or space hardware. Papers on the physiological effects of mechanical vibration and shock on man, pyrotechnic shock, data analysis, and computer aided design are especially welcome. Classification should not exceed Confidential. A summary cover sheet with all necessary information is provided as the last page in this issue and should accompany submitted abstracts. The deadline for abstracts is 31 July, for completed manuscripts, 31 October.

Other

Leo L. Beranek, President of the Institute of Noise Control Engineering (INCE), has announced that a new newsletter, NOISE/NEWS, will be published bimonthly by the Institute. George C. Maling Jr. has been named as editor, and the initial issue (January-February 1972) is now available. NOISE/NEWS is being published in cooperation with the Acoustical Society of America, and will contain information on technical meetings, short courses, standards development, contract information and awards, government news, legislation, items from the Federal Rigister, etc. Subscription rates for calendar year 1972 are $9.00 for individuals and $18.00 to libraries and institutions. Subscriptions may be obtained through the circulation department, NOISE/NEWS, Institute of Noise Control Engineering, P.O. Box 1136, Poughkeepsie, N.Y. 12601.

An intensive one-week seminar on "Vibration of Structures: Current Aspects of Damping and Control" will be held 17-22 September at Pennsylvania State University. The seminar will be of interest and value to engineers and physicists concerned with the reduction and control of structural vibration. Topics for consideration will be simple and complex vibratory systems; material damping; isolation from mechanical vibration and impact; damping of vibrating panels; vibration of beams, plates, and multiframe structures; matrix methods; vibration of shells in vacuo and submerged; and flow-induced vibrations.

Visiting lecturers will be Miguel C. Junger (President, Cambridge Acoustical Associates, Inc.) and Eric E. Ungar (Manager, Applied Physics Department, Bolt Beranek and Newman, Inc., Cambridge, Mass). Pennsylvania State faculty members will be Professors Maurice M. Sevik, Eugen J. Skudrzyk, John C. Snowden, and Harry H. West.

The seminar is intended to provide the participant with a fully up-to-date account of results and techniques for understanding and controlling structural vibrations. It will include a tour of the Garfield Thomas Water Tunnel, which is a complex of test facilities designed for research in fluid dynamics and flow-induced structural vibrations. Each attendee will receive lecture notes and copies of three textbooks for his permanent reference.

Further information may be obtained from John C. Snowdon, Conference Chairman, Ordnance Research Laboratory, The Pennsylvania State University, State College, Pa. 16801

RANDOM VIBRATION AND ACOUSTIC DATA SEMINAR

A seminar on "Random Vibration and Acoustic Data" will be presented in the Washington, D.C. area 5-9 June 1972.

The seminar is intended primarily for working engineers concerned with random vibration and acoustics problems. It will emphasize data acquisition and analysis, along with environmental prediction and design of test specifications. Although aerospace applications will be emphasized, discussions and illustrations will represent real problems arising in automotive, railroad, oceanographic and industrial applications.

The principal lecturer will be Allan G. Piersol, a recognized consultant and author in statistical analysis, interpretation of random physical data, measurement technique and reliability engineering.

The seminar will meet daily at the facilities of COMSAT Laboratories at Clarksburg, Maryland, about 27 miles northwest of Washington. Further information may be obtained from Tustin Institute of Technology, 22 E. Los Olivos, Santa Barbara, California.

NOISE AND VIBRATION CONTROL FOR INDUSTRIALISTS

A three-day conference organized by the Society of Environmental Engineers in conjunction with the Institution of Electronic and Radio Engineers, the University of Bath, and the University of Wales Institute of Science and Technology was held at Bath University 10-12 April. Fourteen papers were presented in an effort to increase awareness of noise and vibration problems and the means of assessment and solution among engineers, architects, consultants and others concerned with these problems in industry. Developments in materials, environmental vibration testing techniques, their availability to firms, and the legal aspects of the subject were reviewed.

ENVIRONMENTAL TEST SPECIFICATIONS

The Society of Environmental Engineers held a half-day symposium on the various test specifications used by engineers in environmental and reliability engineering and product testing. The symposium took place at Imperial College, London on 8 March.

Three papers were presented: "Type Approval of Marine Instrumentation" by H.G. Smith of Sira Institute; "Environmental Considerations in Electronic Equipment Design for Nonmilitary Applications" by B. G. Toms of Plessey Radar; and "An Examination of the Purpose of Environmental Test Specifications" by E. T. Court of Atomic Weapons Research Establishment. The Symposium was chaired by Dr. G. David Reynolds of the British Standards Institution who spoke on BS 9000 and its implications.

DESIGN ENGINEERING CONFERENCE

Virtually every important development in product design will be covered at the Design Engineering Conference to be held 8-11 May, McCormick Place, Chicago. Over 3000 design engineers and executives attend this annual conference sponsored by the Design Engineering Division of ASME. Of particular interest to DIGEST readers is the session "Reducing Vibration Problems in Rotating Machinery." Three papers will be presented in this session:

Balancing High Speed Rotors to Reduce Vibration Levels
Rieger, N. F. (Mech. Tech., Inc.)

Isolation and Absorption of Machinery Vibration
Snowdon, J.C. (Pa. State Univ.)

Identification and Avoidance of Instabilities and Self-Excited Vibrations in Rotating Machinery
Ehrich, F. F. (Gen. Elec. Co.)

For additional information contact Clapp & Poliak, Inc., Show Management, 245 Park Ave., New York, N.Y. 10017.

JUNE

HUMAN ACOUSTICS
Place: Cleveland, Ohio
Dates: June 5-8
Objective: Understanding and practice will be provided in (a) acoustical measurements, (b) procedures for calibrating hearing aids and air and bone conduction audiometers, and (c) procedures for Walsh-Healey noise exposure measurements.

Contact: Director of Communications, B&K Instruments, Inc., 5111 West 164th St., Cleveland, Ohio 44142

ACOUSTICAL MATERIALS AND STRUCTURES: DESIGN, TESTING AND APPLICATIONS
Place: Cleveland, Ohio
Dates: June 5-8
Objective: The measurement of transmission loss, sound absorption, and vibration damping of materials and structures in laboratory and field situations will be studied.
Contact: Director of Communications, B&K Instruments, Inc., 5111 West 164th St., Cleveland, Ohio 44142

AIRCRAFT NOISE, THEORY AND APPLICATIONS
Place: Univ. Tenn. Space Inst.
Dates: June 5-9
Objective: The present knowledge on aircraft noise, its generation effects and control will be surveyed. Emphasis will be on the understanding of the physical nature of the noise sources based on available test and measurement data. The discussion will include noise data from subsonic and supersonic aircraft and rockets, general aerodynamic noise theory, jet noise and compressor noise, methods of noise reduction, boundary-layer noise, atmosphere propagation and absorption, psychological effects and operational methods.

Contact: Jules Bernard, Manager Short Course Programs, Univ. Tenn. Space Inst., Tullahoma, Tenn. 37388

INSTRUMENTATION FOR TECHNICAL ANALYSIS
Place: Univ. Mich.
Dates: June 5-16
Objective: An introductory lecture and laboratory course will be offered to give engineers the ability to use strain gages, precision potentiometers, differential transformers, light-sensing devices, and the analog computer to analyze mechanical systems.

Contact: Engr. Summer Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

MATRIX COMPUTATION
Place: Univ. Mich.
Dates: June 19-23
Objective: A careful study of current algorithms for the solution of matrix problems, especially algebraic eigenvalue problems will be presented. Both theoretical and computational aspects will be considered.

Contact: Engr. Summer Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

NUMERICAL METHODS, OPTIMIZATION TECHNIQUES, AND SIMULATION FOR ENGINEERS
Place: Univ. Mich.
Dates: June 19-30
Objective: The application of digital computers, numerical methods, and optimization techniques to chemical and mechanical engineering problems will be discussed including simulation of process equipment.

Contact: Engr. Summer Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

NUMERICAL ANALYSIS AND DIGITAL COMPUTER METHODS IN ENGINEERING
Place: Univ. Calif. (L.A.)
Dates: June 19-30
Objective: This course will familiarize engineers working in the design and analysis of engineering systems with numerical analysis and digital computer methods. Emphasis will be placed on the theoretical background of numerical applications to various fields of engineering and computer techniques in arriving at numerical solutions.

Contact: P. O. Box 24902, Continuing Ed. Engr. Sci., Univ. Extension, UCLA, Los Angeles, Calif.

ADVANCED ELECTRONIC INSTRUMENTATION FOR ENGINEERS
Place: Univ. Mich.
Dates: June 26-30
Objective: This course has been designed to provide the practicing engineer with a broad exposure to electronic instrumentation. This will materially enhance his capability to solve real-time instrumentation problems found in manufacing plants today. The course will include lectures, demonstrations, and laboratory work.
Contact: Engr. Summer Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

JULY

DYNAMICS OF VEHICLES AND OCCUPANTS IN SEVERE MOTION
Place: Univ. Mich.
Dates: July 10-14
Objective: The use of the digital computer and computer graphic terminals in predicting motions and forces in vehicles and vehicle occupants under conditions of severe maneuvers and crash will be examined.
Contact: Engr. Summer. Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

AUGUST

NOISE REDUCTION IN MECHANICAL SYSTEMS: FUNDAMENTALS AND ADVANCED CONSIDERATIONS
Place: Univ. Mich.
Dates: Aug. 7-18
Objective: Practicing engineers and engineering management will be offered an up-to-date, comprehensive, and practical working knowledge of noise reduction engineering and criteria for allowable noise.
Contact: Engr. Summer Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

MOTOR VEHICLE PERFORMANCE -- MEASUREMENT AND PREDICTION
Place: Univ. Mich.
Dates: Aug. 16-18
Objective: The advances being made to make the measurement and assessment of motor vehicle performance (braking, cornering, roadholding, ride, etc.) a highly objective activity will be emphasized.
Contact: Engr. Summer Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

VIBRATION AND SHOCK TESTING
Place: Santa Barbara, Calif.
Dates: Aug. 21-25
Objective: The course is designed for quality assurance, evaluation and test personnel who are concerned with maximum reliability of missiles, aircraft, submarines, electronics, process industries, etc., where vibration and shock are hazardous environments. The seminar will concentrate on modern laboratory practice, equipment and techniques with a minimum of theory and mathematics.
Contact: Tustin Inst. Tech., Inc., 22 E. Los Olivos St., Santa Barbara, Calif. 93105

ABSTRACT CATEGORIES FOR THE SHOCK AND VIBRATION DIGEST

ANALYSIS AND DESIGN

- Analogs and Analog Computation
- Analytical Methods
- Impedance Methods
- Integral Transforms
- Nonlinear Analysis
- Numerical Analysis
- Optimization Techniques
- Perturbation Methods
- Stability Analysis
- Statistical Methods
- Variational Methods
- Finite Element Modeling
- Modeling
- Computer Programs
- Digital Simulation
- Parameter Identification
- Design Information
- Design Techniques
- Standards and Specifications
- Surveys
- Tutorial

ENVIRONMENTS

- Acoustic
- Periodic
- Random
- Seismic
- Shock
- General Weapon
- Transportation

PHENOMENOLOGY

- Composite
- Damping
- Elastic
- Fluid
- Inelastic
- Soil
- Thermoelastic
- Viscoelastic

EXPERIMENTATION

- Data Reduction
- Diagnostics
- Equipment
- Experiment Design
- Facilities
- Instrumentation
- Procedures
- Scaling and Modeling
- Simulators
- Specifications
- Techniques

COMPONENTS

- Absorbers
- Beams, Strings, Rods
- Bearings
- Blades
- Columns
- Controls
- Ducts
- Frames
- Gears
- Isolators
- Linkages
- Mechanical
- Membranes
- Panels
- Pipes
- Plates and Shells
- Rings
- Springs
- Structural

SYSTEMS

- Absorber
- Acoustic Isolation
- Active Isolation
- Aircraft
- Artillery
- Bioengineering
- Bridges
- Building
- Cabinets
- Construction
- Earth
- Electrical
- Helicopters
- Human
- Isolation
- Material Handling
- Mechanical
- Metal Working and Forming
- Off-Road Vehicles
- Optical
- Package
- Pressure Vessels
- Pumps, Turbines, Fans, Compressors
- Rail
- Reactors
- Reciprocating Machine
- Road
- Rotors
- Satellite
- Self-Excited
- Ship
- Spacecraft
- Structural
- Transmissions
- Turbomachinery
- Useful Application

DOCUMENT INFORMATION

Copies of articles abstracted are not available from the Shock and Vibration Information Center (except for those generated by SVIC). Inquiries should be directed to library resources, authors, or the original publishers. According to prefixed letters on document numbers, articles can be obtained from the following agencies:

AD, N } Defense Documentation Center, Document Library, Cameron Station, Alexandria, Va. 22314

ASME - American Society of Mechanical Engineers, 345 E. 47th St., New York, N.Y. 10017

NASA - National Aeronautics and Space Administration, Scientific and Technical Information Division, Washington, D.C. 20546

NSA - Superintendent of Documents, U.S. Government Printing Office. Washington, D.C. 20402 (or NTIS)

PB - National Technical Information Service, Dept. Commerce, Springfield, Va. 22151

SAE - Society of Automotive Engineers, 2 Pennsylvania Plaza, New York, N.Y. 10001

Patent descriptions should be requested from the U. S. Patent Office, Washington, D. C. 20231. Doctoral theses are available from University Microfilms (UM), 313 No. Fir St., Ann Arbor, Mich.

Addresses following the authors' names in the abstracts refer only to the first author listed.

ANALYSIS AND DESIGN METHODS

ANALOGS AND ANALOG COMPUTATION

72—539

HYBRID ELECTROMECHANICAL ANALOG COMPUTER TECHNIQUE FOR OPTIMIZING VIBRATION SYSTEMS
Masri, S.F. and Ibraiim, A.M. (Univ. S. Calif., Los Angeles, Calif.)
ASME Paper No. 71-Vibr-119

Key Words: analogs, optimization, vibration response

A simple and efficient real-time simulation method is presented for investigating certain classes of vibration problems by employing a hybrid electromechanical analog computer. The response of a two degree-of-freedom system equipped with an impact damper is investigated. The effects of mode shape, frequency ratio, mass ratio, coefficient of restitution, and damper clearance ratio on the response of the system are determined.

ANALYTICAL METHODS

(Also see Nos. 564, 565, 566, 595, 662, 751)

72—540

DYNAMIC ELASTICITY BY THE THEORY OF CHARACTERISTICS
Buchanan, G.R.; Phung, C.H.; and Huang, J.C. (Dept. Engr.Sci., Tenn. Tech. Univ., Cookeville, Tenn.)
NASA-CR-123178, 14 pp (Sept. 1970)

Key Words: dynamic elasticity, theory of characteristics

A characteristic analysis is presented for the equations of elasticity in Cartesian coordinates. The characteristic slope equations are derived and it is verified that two types of waves exist. The compatibility equations are developed in relation to the direction cosines of a spherical coordinate system. A brief discussion of the method of analysis is included.
N71-38705

72—541

THE LOADING-FREQUENCY RELATIONSHIP IN MULTIPLE EIGENVALUE PROBLEMS
Huseyin, K. and Roorda, J.
J. Appl. Mech. Trans. ASME 38 (4), 1007-1011 (Dec. 1971)
11 refs

Key Words: eigenvalue problems, free vibration

The free vibrations of a linear conservative system with multiple loading parameters are studied. Attention is restricted to pure eigenvalue problems. The smallest frequency and external loading parameters of such a system constitute a strictly convex (synclastic) surface which cannot have convexity toward the origin of the "parameter space." In the case of systems with one degree of freedom only, the surface takes the form of a plane. The practical implications of these results are discussed. On the basis of the established theorems, lower bounds to the frequencies at any stage of external loading and/or upper bounds to the stability boundary are readily obtainable. A two degree-of-freedom example is discussed.

72—542

GUYAN REDUCTION SOLUTIONS RECYCLED FOR IMPROVED ACCURACY
Levy, R. (Jet Propulsion Lab., Pasadena, Calif.)
Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 19 pp
8 refs

Key Words: Guyan reduction method, natural frequencies, structural dynamics

The accuracy of conventional solutions of the eigenvalue problem by means of the Guyan reduction method is examined for analytical models of several practical structures. Evaluations are made of eigenvalue accuracy with respect to the relative numbers of retained indicator degrees of freedom. When a relatively small number of indicator degrees of freedom are employed, solutions are likely to be inaccurate unless prior knowledge of the mode shapes is used in selecting these degrees of freedom.

72—543

A HYBRID METHOD OF COMPONENT MODE SYNTHESIS
MacNeal, R.H. (MacNeal-Schwendler Corp., 7442 N. Figueroa St., Los Angeles, Calif.)
Computers and Struc. 1(4), 581-601 (Dec. 1971) 12 refs

Key Words: component mode synthesis

A method is described for representing a structural component by means of its vibration modes. The modes used to describe the component may have the connection points to the remainder of the structure free, or fixed, or some points free and some points fixed. The modes may either be calculated or experimentally measured. Statically determined deflection influence coefficients may be used to improve the accuracy of the representation. The advantages claimed for the method derive from the generality of the conditions under which the component modes are calculated (or measured). Thus the boundary conditions may be selected to optimize accuracy or, in the event that the modes have already been obtained, the method permits the available data to be used. Examples are presented that illustrate use of the method, and the significance of the improvements derived from static calculations.

72—544

FREE VIBRATION OF GRID-STIFFENED PLATES
Omid'varan, C. (Dept. Civil Engr., Univ. New Mex., Albuquerque, New Mex.)
J. Sound and Vib. 19(4), 463-472 (Dec. 22, 1971) 26 refs

Key Words: beam-grids, periodic excitation, plates, stiffened plates

A closed functional solution is formulated for the expression of the steady state frequencies of vibration of a simply supported plate stiffened by a grid. The grid properties are assumed to be different in orthogonal directions. The plate-grid interactions are assumed to consist of only normal forces at the node points.

72—545

NORMAL-MODE AND RAY THEORY APPLIED TO UNDERWATER ACOUSTIC CONDITIONS OF EXTREME DOWNWARD REFRACTION
Pedersen, M.A. and Gordon, D.F. (Naval Undersea R & D Ctr., San Diego, Calif.)
J. Acoust. Soc. Am. 51(1), 323-368 (Jan. 1972) 18 refs

Key Words: normal modes, underwater sound

The acoustic field in the image-interference and shadow-zone regions for a model in which the sound velocity decreases with increasing depth from the surface is investigated. The mode theory results are compared with those of ray theory. There is a $-\pi/2$ jump in the ray theory phase when the ray touches a caustic but there is no such jump when the ray becomes horizontal. The normal-mode series is convergent for ranges greater than 1.732 times the sum of the source and receiver depths. When the shadow zone is bounded by a well-developed caustic, convergence occurs so slowly as to be impractical except at ranges well into the shadow zone region.

72—546

APPLICATIONS OF GENERALIZED INVERSES TO ESTIMATION IN DYNAMIC SYSTEMS
Prochaska, B.J. (Clemson Univ., Clemson, S.C.)
J. Dynamic Syst. Measurement and Control, Trans. ASME 93(4), 252-256 (Dec. 1971) 12 refs

Key Words: matrix inverses, state vectors

Generalized matrix inverses are used to obtain a procedure for estimation of the state vector of a dynamic system. This procedure is studied analytically with respect to the choice of an arbitrary vector. The covariance matrix of the estimator is determined and compared to the Kalman type procedure.

72—547

THE EIGENVALUE PROBLEM FOR BANDED MATRIXES
Weaver, W., Jr. and Yoshida, D.M. (Dept. Civil Engr., Stanford Univ., Stanford, Calif.)
Computers and Struc. 1(4), 651-644 (Dec. 1971) 10 refs

Key Words: eigenvalue problems, matrix methods

The generalized Lanczos method is used for the purpose of calculating frequencies and mode shapes for linearly elastic discretized structures where the energy-consistent stiffness and mass matrixes are equally banded. This approach involves reduction of the problem to standard eigenvalue form without expanding the bandwidth of either of the original arrays. Applications of the method to both vibrational and buckling analyses indicate its potential for conserving core storage when solving the eigenvalue problem on a digital computer.

INTEGRAL TRANSFORMS
(Also see No. 598)

72—548
AN INTEGRAL EQUATION APPROACH TO THE FUNDAMENTAL FREQUENCY OF VIBRATING BEAMS
Penny, J.E. and Reed, J.R. (Dept. Mech. Engr., Univ. Aston in Birmingham, Birmingham B47ET, England)
J. Sound and Vib. 19(4), 393-400 (Dec. 22, 1971)

Key Words: beams, natural frequency

An approximation to the lowest natural frequency of vibrating beams is obtained analytically by applying eigenvalue, eigenfunction theory to the defining integral equation. The method produces successively closer values for both upper and lower bounds to the fundamental frequency. It is found that the second lower bound provides in itself a good approximation to published values and a graph is derived which provides a bound for the error in this approximation without further computation.

NONLINEAR ANALYSIS
(Also see Nos. 625, 745)

72—549
COMPLEX ENVELOPES FOR OSCILLATIONS IN SLIGHTLY NONLINEAR SYSTEMS
Pierce, W.H. (Elec. Engr. Dept., Univ. Louisville, Louisville, Ky.)
J. Appl. Mech., Trans. ASME 38(4), 1012-1016 (Dec. 1971)

Key Words: nonlinear systems, oscillation

A complex envelope f(t) is used to replace the traditional sine and cosine envelopes of the response of a sinusoidally forced, slightly nonlinear system. The response becomes $y(t) = Re[f(t)\, e^{j\omega t}]$. By setting $Im[f(t)\, e^{j\omega t}]$ equal to the Hilbert transform of y(t), simple equations for the derivative of f(t) are easily obtained. The approximations implicit in the method of averaging introduce broadband filtering. These effects can be eliminated by the use of all harmonics. An example of an off-center rotary load shaken by a general elliptical motion is used to show how resonant modes of the device's mount can be selectively energized at different frequencies, provided the models have high Q and adequate separation of resonant frequency.

NUMERICAL ANALYSIS

72—550
ON THE STABILITY OF EXPLICIT METHODS FOR THE NUMERICAL INTEGRATION OF THE EQUATIONS OF MOTION IN FINITE ELEMENT METHODS
Fu, C.C. (Ingersoll-Rand Res., Princeton, N.J.)
Intl. J. Numer. Methods Engr. 4, 95-107 (Jan./Feb. 1972)

Key Words: equations of motion, finite element technique, numerical analysis

The stability of the numerical solutions of a dynamic finite element analysis is examined. The solutions are obtained through a stepwise integration of the equations of motion. Upper bounds on the steplength of the integration are obtained from a stability analysis of using a simple finite difference approximation for the equations of motion, and are shown to depend strongly on the particular element in use and on how the mass of the element is distributed at its nodes.

OPTIMIZATION TECHNIQUES
(Also see No. 539)

STABILITY ANALYSIS
(Also see Nos. 554, 558, 648, 668, 672, 673, 713)

STATISTICAL METHODS
(Also see Nos. 724, 738, 753)

72—561
STATISTICAL LINEARIZATION FOR NONLINEAR STRUCTURES
Iwan, W.D. and Yang, I.
J. Engr. Mech. Div., Proc. ASCE 97(EM6), 1609-1623 (Dec. 1971) 8 refs

Key Words: nonlinear systems, statistical linearization

An approach for determining approximate instantaneous correlation function matrixes of the response of a nonlinear structure to nonwhite excitation is presented. The approach is based on the concept of statistical linearization and is not subject to many of the restrictions placed

on other methods. In addition, the approximating procedure is capable of a natural physical interpretation. An example of the application of the approximate approach to a softening structure is given.

72—552

ON THE FIRST EXCURSION PROBABILITY IN STATIONARY NARROWBAND RANDOM VIBRATION
Yang, J.N. and Shinozuka, M. (Appl. Mech. Section, Jet Propulsion Lab., Pasadena, Calif.)
J. Appl. Mech., Trans. ASME 38 (4), 1017-1022 (Dec. 1971) 16 refs

Key Words: random vibration

A number of approximate solutions are derived for a stationary narrowband Gaussian process X(t) with mean zero. The point process approach is used. In particular, upper and lower bounds sharper than those presently available are established, an approximation based on the Markov point process is obtained, and the clump size approach is used. These approximations are checked with the result of the semisimulation performed by Crandall, et al in an earlier study.

VARIATIONAL METHODS

72—553

ON THE ANALYSIS OF WAVEGUIDES OF DOUBLY-CONNECTED CROSS SECTION BY THE METHOD OF CONFORMAL MAPPING
Laura, P.A.; Romanelli, E.; and Maurizi, M.J. (Departamento de Ingenieria, Universidad Nacional del Sur, Alem 1253, Bahia Blanca, Argentina)
J. Sound and Vib. 20 (1), 27-38 (Jan. 8, 1972) 24 refs

Key Words: conformal mapping, waveguides

The determination of cutoff frequencies in waveguides of arbitrary, doubly-connected cross section is discussed. The given domain is transformed into an annular region and the transformed partial differential equation is solved by means of a variational technique. Calculations are presented for acoustically soft waveguides of regular polygonal shape with circular inner boundaries. The problem is mathematically equivalent to the determination of TM modes in electromagnetic waveguides.

72—554

ADJOINT VARIATIONAL METHODS IN NONCONSERVATIVE STABILITY PROBLEMS
Prasad, S.N. and Herrmann, G. (Univ. Miss., University, Miss.)
Intl. J. Solids Struc. 3 (1), 29-40 (Jan. 1972) 27 refs

Key Words: eigenvalue problems, variational methods

A general nonself-adjoint eigenvalue problem is examined and it is shown that the commonly employed approximate methods (such as the Galerkin procedure, the method of weighted residuals and the least square technique) lack variational descriptions. When used in their previously known forms they do not yield stationary eigenvalues and eigenfunctions. With the help of an adjoint system, however, several analogous variational descriptions may be developed. By properly restating the method of least squares, stationary eigenvalues may be obtained. Several properties of the adjoint eigenvalue problem, known only for a restricted group, are shown to exist for the more general class selected.

FINITE ELEMENT MODELING

(Also see Nos. 550, 736)

72—555

THE TREATMENT OF RANDOMNESS IN FINITE ELEMENT MODELING
Hart, G.C. and Collins, J.D. (Mech. Struc. Dept., Univ. Calif., Los Angeles, Calif.)
SAE Paper No. 700842 (Oct. 5-9, 1970

Key Words: finite element technique, mathematical models, statistical analysis

A linear statistical model is developed for analyzing the statistics of response of static and dynamic finite element models. The model uses the statistical moments of random physical properties (for example, modulus of elasticity) to establish the degree of uncertainty in computed static deflections, frequencies, and buckling loads. A sample problem is included showing the influence of property variance and covariance upon all three areas of interest.

72—556

ANALYSIS OF NONLINEAR, DYNAMIC COUPLED THERMOVISCOELASTICITY PROBLEMS BY THE FINITE ELEMENT METHOD

Oden, J.T. and Armstrong, W.H. (Engr. Mech., Univ. Ala., Huntsville, Ala.)

Computers and Struc. 1(4), 603-621 (Dec. 1971) 2^ refs

Key Words: cylindrical shells, finite element technique, thermoviscoelasticity, transient response

This investigation deals with the numerical solution of a class of nonlinear problems in transient, coupled, thermoviscoelasticity. Equations of motion and heat conduction are derived for finite elements of thermomechanically simple materials and these are adapted to special classes of thermorheologically simple materials. The analysis involves the solution of large systems of nonlinear integrodifferential equations in the nodal displacements and temperatures and their histories. As a representative example, the general equations are applied to the problem of the transient response of a thick-walled hollow cylinder subjected to time-varying internal and external pressures, temperatures, and heat fluxes. The integration scheme used employs a linear acceleration assumption, a representation of nonlinear integral terms by Simpson's rule, and the iterative solution of large systems of nonlinear algebraic equations at each reduced time step by the Newton-Raphson method. Various numerical results are given and are compared with the linearized, isothermal, and quasi-static solutions.

72—557

MODE SHAPES AND FREQUENCIES BY FINITE ELEMENT METHOD USING CONSISTENT AND LUMPED MASSES

Tong, P.; Pian, T.H.H.; and Bucciarelli, L.L (School Engr., Mass. Inst. Tech., Cambridge, Mass.)

Computers and Struc. 1(4), 623-638 (Dec. 1971) 8 refs

Key Words: finite element technique, mode shapes, natural frequencies

The rate of convergence of the mode shapes and frequencies by the finite element method using consistent and lumped mass formulations has been established. Simple examples are given to demonstrate the results. It is shown that for a system of differential equations of second order, such as the equations of equilibrium in terms of displacement in the theory of elasticity, membrane etc., a proper lumped mass formulation does not suffer any loss of rate of convergence utilizing simple elements. However, in the case of higher order differential equations or when the use of more complicated elements is required or desired, a consistent mass formulation often provides a better rate of convergence.

MODELING

(Also see Nos. 543, 568, 614, 627, 651, 653, 656, 657, 702, 727)

72—558

A COMBINED TIME-FREQUENCY CONDITION FOR STABILITY OF TIME-VARYING SYSTEMS WITH ONE NONLINEARITY

Blodgett, R.E. and Young, K.P. (Res. Ctr., Kearfort Div., Singer-General Precision, Inc., Little Falls, N.J.)

J. Dynamic Syst., Measurement, and Control, Trans. ASME 93(4), 251-267 (Dec. 1971)

Key Words: minimization, stability

A means for determining stability of linear time-varying systems with one feedback nonlinearity is presented. The stability condition involves the minimization of certain time functions of the system coefficients and the imaginary axis behavior of a polynomial. The equation of the linear time-varying system must be asymptotically stable and in phase variable form. Also, the nonlinearity is restricted to lie in a sector.

72—559

PROPAGATION OF FLEXURAL WAVES IN DOUBLY-PERIODIC STRUCTURES

Gupta, G.S. (Engr. Sci. Data Unit, Royal Aeronaut. Soc., 251-259 Regent St., London W1R7AD, England)

J. Sound and Vib. 20(1), 39-49 (Jan. 8, 1972) 8 refs

Key Words: flexural waves, natural frequencies, periodic structures

A study of free wave propagation in doubly-periodic structures consisting of the repetition of a basic unit which is a periodic structure in itself is presented. The propagation zones in these structures are distributed in a pattern which is to some extent doubly-periodic in nature. The bounding frequencies of the pattern zones are identified with the natural frequencies of the multispan structure constituting the basic unit with various end conditions. The analysis is simplified by introducing a direct- and a cross-chain-receptance for the multispan structure

and by utilizing the concept of the equivalent internal restraint. The natural frequencies of a finite, doubly-periodic structure are then easily obtained from the propagation constant-frequency parameter diagram.

72—560

DYNAMIC ANALYSIS OF LARGE STRUCTURES BY MODAL SYNTHESIS TECHNIQUES
Hurty, W.C.; Collins, J.D.; and Hart, G.C. (J.H. Wiggins Co., Palos Verdes Estates, Calif.; also Univ. Calif., Los Angeles, Calif.)
Computers and Struc. 1(4), 535-563 (Dec. 1971) 13 refs

Key Words: component mode synthesis

The past decade has seen the development of several techniques for the dynamic analysis of large structures that involve division into substructures or components. These techniques make use of component displacement modes to synthesize global systems of generalized coordinates and, for that reason, they have come to be known as modal synthesis or component mode techniques. Some of the approaches used to develop structural dynamic characteristics from substructure dynamic characteristics are reviewed. Several criteria that may be used to evaluate the merits of the various methods are discussed. Two methods (1) fixed-attachment mode, and (2) free-attachment mode, are developed in detail. General flowcharts are presented that can be used in preparing computer programs.

72—561

ON THE FINITE DEFLECTION DYNAMICS OF THIN ELASTIC BEAMS
Lee, S.Y. (Dept. Mech. and Hydr., Univ. Iowa, Iowa City, Iowa)
J. Appl. Mech., Trans. ASME 38(4), 961-963 (Dec. 1971) 9 refs

Key Words: beams, dynamic response, linear systems, rotatory inertia, transverse shear deformation

A dynamic theory is derived of thin beams undergoing large deflection but small strain. Geometric nonlinearities are preserved. The material is assumed to behave linearly and contributions from rotatory inertia, shear deformation, and axial stress resultants are included. Characteristic techniques are used to analyze the resulting equations. Wave propagtion speeds, jump properties, and the physical significance of these are discussed. A simplifying assumption generates a modified Timoshenko beam equation which is valid for large deformation problems.

72—562

A GENERALIZED FORMULATION OF THE VECTORIAL EQUATIONS OF MOTION FOR NONPRISMATIC THIN SPACE BEAMS
Massoud, M.F. (Mech. Engr. Dept., Univ. Sherbrooke, Sherbrooke, P.Q., Canada)
J. Appl. Mech., Trans. ASME 38(4), 955-960 (Dec. 1971) 8 refs

Key Words: equations of motion, rotary inertia, thin beams, transverse shear deformation

A generalized vectorial equation of motion for small vibrations of any nonprismatic thin beam for which the centerline is an arbitrary space curve, is presented. Any characteristic dimension of any cross section is assumed to be small compared to the local radii of curvature and geometric torsion for the beam. The equations of motion are given in terms of a linear displacement vector of the centroid of the cross section, and a rotation displacement vector about the centroid. A brief discussion of the boundary conditions is given. Both the effects of rotary inertia and the shear deformation upon the general derived expressions are discussed.

72—563

REINFORCED CONCRETE EXTERIOR BEAM-COLUMN JOINTS UNDER SEISMIC LOADING
Megget, L.M. and Park, R.
New Zealand Engr. 26(11), 341-353 (Nov. 15, 1971) 16 refs

Key Words: beams, joints (junctions), reinforced concrete, seismic excitation

An experimental investigation into the behavior of exterior beam-column joints of reinforced concrete frames with low axial load is described. Three beam-column test units designed by different methods are tested under the same program of static cyclic loading and compared. The design parameters examined are the methods of anchoring the longitudinal beam reinforcement within the column and the amount of transverse shear reinforcement within the joint region. The joints of all three specimens prove to be inadequately reinforced to resist the large joint shears present under intense seismic loading conditions in the inelastic range.

72—564

USE OF TRIGONOMETRIC TERMS IN THE FINITE ELEMENT METHOD WITH APPLICATION TO VIBRATING BARS AND MEMBRANES
Milsted, M.G., Jr.
139 pp (1971)

Key Words: bars, beams, eigenvalue problems, finite element technique, membranes, rods

A study to determine if high-order finite elements using trigonometric terms would be useful for solving one- and two-dimensional eigenvalue problems is presented. The investigation is limited to compatible displacement solutions where the element displacement fields are taken to be sums of fixed degree polynomials plus arbitrary numbers of trigonometric terms. Several one-dimensional elements are developed and tested on vibrating rod and beam problems. For a given number of system degrees of freedom, natural frequency calculations obtained from the trigonometric elements compare favorably with results obtained in other ways.
UM 72-3594

COMPUTER PROGRAMS
(Also see Nos. 720, 721)

72—565

PRACTICAL ANALYSIS OF PLATE VIBRATIONS USING NASTRAN
Clary, R.R. (NASA-Langley Res. Ctr., Hampton, Va.)
Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 16 pp, 3 refs

Key Words: computer programs, finite element technique, flutter, NASTRAN, natural frequencies, plates

This paper discusses the successful application of the NASA structural analysis computer program (NASTRAN) to the calculation of the vibration characteristics of a variety of plate configurations. Calculated natural frequencies and nodal patterns are generally in good agreement with measured data for: (1) research filamentary composite material plates; (2) wing flutter models fabricated with metal reinforced with composite material; and (3) a metal plate supported on an elastic boundary.

72—566

NASTRAN MODELING STUDIES IN THE NORMAL MODE METHOD AND NORMAL MODE SYNTHESIS
Courtney, R.L. (NASA-Goddard Space Flight Ctr.)
Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 18 pp, 15 refs

Key Words: beams, computer programs, finite element technique, NASTRAN, normal modes, spacecraft

The results of finite element and analytic solutions of the normal modes of a uniform beam under various end conditions are compared. The normal modes of a single component are synthesized to represent different single-component and multicomponent structures. The results are compared for accuracy with the analytic structural solutions. Guidelines for finite element structural modeling are developed which determine the minimum number of elements required to obtain specified levels of accuracy in normal mode analysis and synthesis. The finite element modeling studies are implemented on NASA's NASTRAN structural analysis computer program. Modeling techniques that represent a part of a structure by its normal modes in a computer structural analysis are presented.

72—567

ADAPTATION OF NASTRAN TO THE ANALYSIS OF THE VIKING SPACE VEHICLE
Jones, T.C. and Pinson, L.D. (NASA-Langley Res. Ctr., Hampton, Va.)
Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 19 pp, 7 refs

Key Words: finite element technique, missile launchers, NASTRAN, normal modes

A normal mode analysis of the complete Viking launch vehicle (stage 1, shutdown configuration) using a modification of NASTRAN Version 11.1.0 on the CDC 6600 computer system is presented. The operational and logistics problems discussed are typical of those encountered in the use of NASTRAN for any large problem. The vehicle is divided into three basic substructures which are modeled and checked separately, then joined to yield a complete, unreduced model of the system. Eigenvalues are extracted using the inverse power method. The results of this study demonstrate the broad versatility of NASTRAN for simultaneously modeling structures by direct

matrix input, general elements, and rigid links along with the standard library of finite elements. It also indicates the large computer time requirements of NASTRAN for extracting roots of large order matrixes.

72—568

USE OF HIGH-LEVEL PROCEDURAL LANGUAGES IN DYNAMICS
Lopez, L.A. (Civil Engr., Univ. Ill., Urbana, Ill.)
Computers and Struc. 1(4), 565-580 (Dec. 1971) 6 refs

Key Words: digital computation, lumped parameter models, POST

The solution of complex problems concerning wave propagation in plane and axisymmetric continua can be obtained through the use of discrete methods of analysis. Invariably these methods introduce mathematical models involving thousands of degrees of freedom. Programing the solution to these problems in a standard procedural language such as FORTRAN generally results in a large lag time between problem inception and program completion. In many instances, a shorter development time which results in a moderately efficient program is a more economical and hence, a more desirable approach. The purpose of this paper is to demonstrate that a high-level procedural language such as POST is a much more natural language than FORTRAN in which to express the solution of wave propagation problems. The lumped parameter method of analysis is used to determine the solution.

PARAMETER IDENTIFICATION

72—569

AUTOMATED DESIGN PARAMETER IDENTIFICATION: A NEW APPROACH
Sevin, E. (Univ. Negev, Beer-Sheva, Israel)
ASME Paper No. 71-Vibr-116

Key Words: dynamic systems, parameter identification

Described is a new method for automatically identifying design parameters in dynamical systems, i.e., in systems whose basis of design depends upon the response to time-dependent loads. The "system" is considered to be an assemblage of structural and mechanical elements, all specified as to configuration but some requiring selection of parameters. These are termed the "design parameters" and are the problem unknowns. The method is described in terms of two examples prior to presenting a general formulation for a limited, but large, class of systems. Finally, the broad outlines of an automated procedure are suggested.

DESIGN INFORMATION

72—570

ON THE INTERPRETATION AND APPLICATION OF SHOCK TEST RESULTS IN ENGINEERING DESIGNS
Mok, C.H. (Reentry and Envir. Syst. Div., Gen. Elec. Co., Philadelphia, Pa.)
8 pp (1970)

Key Words: equipment response, shock response spectra, shock tests

A theoretical study of the characteristics of a shock spectrum which is measured in a shock test of equipment is presented. The machine and the equipment are represented by two systems connected in series. An upper and a lower bound of the spectrum of the shock motion at the interface of the two systems are found using the Fourier transform and impedance method. The spectrum is shown to be affected by the characteristics of both systems. It is demonstrated that in a system containing negligible damping, hills would occur in the spectrum at the resonant frequencies of the combined system; whereas valleys (spectrum dips) would appear in the neighborhood of the fixed-base resonant frequencies of the equipment. The possible effects of damping and of the variation in the characteristics of the system on the phenomenon are also discussed.
AD-733591

DESIGN TECHNIQUES

72—571

HOW SIMULATION PREDICTS PRODUCT BEHAVIOR...OR MISBEHAVIOR
Montgomery, D.C. (Ga. Inst. Tech., Atlanta, Ga.)
Mach. Design 43(23), 128-134 (Sept. 16, 1971)

Key Words: mathematical models, structural response

The simulation of an entire product with equations to predict how well it will work is discussed.

SURVEYS

72—572

DIFFRACTION THEORY: A BRIEF INTRODUCTORY REVIEW
Jones, D.S. (Dept. Math., Univ. Dundee DD1 4HN, Scotland)
J. Sound and Vib. 20(1), 71-78 (Jan. 8, 1972) 18 refs

Key Words: aerodynamic characteristics, sound waves, wave diffraction

A brief review of the fundamentals of diffraction theory, especially insofar as these may be relevant to the theory of aerodynamic noise, is presented. Attention is drawn to the different behaviors to be expected at low and high frequencies. The problem of determining the properties of a medium from the acoustic field scattered by it is mentioned.

TUTORIAL
(Also see No. 578)

ENVIRONMENTS

ACOUSTIC
(Also see Nos. 545, 572, 600, 601, 612, 613, 649, 677, 679, 681, 682, 683, 694, 699, 711, 712, 725, 736, 758, 759, 761, 764)

72—573

NEARFIELD EFFECTS IN PARAMETRIC END-FIRE ARRAYS
Berktay, H.O. (Appl. Res. Labs., Univ. Tex. at Austin, 10000 FM Rd. 1325, Austin, Tex.)
J. Sound and Vib. 20(2), 135-143 (Jan. 22, 1972) 10 refs

Key Words: sound directivity, waves

An attempt is made to explain some of the discrepancies observed between experimental directivity patterns of parametric end-fire arrays and those calculated on the assumption of simplified models. It is shown that some of the effects can be explained by making allowance for the observer being at a finite range. The results also show that if the nonlinear interaction between primary waves takes place within the Fresnel region of the projector, this may cause a slight reduction in the difference frequency pressure in the farfield, but has very little effect on its directivity pattern.

72—574

SCATTERING OF SOUND WAVES BY ROTATING CYLINDERS AND SPHERES
Censor, D. and Aboudi, J. (Dept. Envir. Sci., Tel Aviv Univ., Ramat-Aviv, Israel)
J. Sound and Vib. 19(4), 437-444 (Dec. 22, 1971) 16 refs

Key Words: rotating structures, sound waves, wave diffraction

The wave equation for sound waves in uniformly rotating systems is derived and is applied to the problems of scattering of sound waves by uniformly rotating cylinders and spheres. Rotation introduces an effective modal wave velocity. The boundary conditions are taken as the continuity of pressure and normal displacement. It is shown that scattering exists even if the objects and the external media have the same parameters in their proper frames. For the cylinder problem computational results are given for the scattering amplitude for various angular velocities and angles of incidence. It is shown that the sphere problem is separable only for slow rotation.

72—575

NATURAL RESONANT FREQUENCIES OF AN OBLATE ACOUSTICAL RESONATOR
Chang, C.T.M. (Argonne Nat. Lab., Argonne, Ill.)
J. Acoust. Soc. Am. 51(1), 1-5 (Jan. 1972) 5 refs

Key Words: acoustic resonance, natural frequencies, resonators

Natural resonant frequencies of oblate acoustical resonators with either perfectly soft or perfectly rigid boundaries are calculated. This is achieved by locating the zeros of $R_{mn}^{(1)}(-ih, \xi)$ and $R_{mn}^{(1)\prime}(-ih, \xi)$. These frequencies are normalized to those of the corresponding modes of a spherical cavity with the same volume. Results are presented for various ratios of major to minor axes.

72—576

NOISE REDUCTION BY MEANS OF VARIABLE GEOMETRY INLET GUIDE VANES IN A CASCADE APPARATUS
Chestnut, D. and Clark, L.R. (NASA-Langley Res. Ctr., Hampton, Va.)
NASA-TM X-2392, 24 pp (Oct. 1971)

Key Words: aerodynamic excitation, cascades, noise reduction

Noise reduction studies involving variable geometry inlet guide vanes for choking are made by using a two-sector cascade apparatus with three different inlet configurations; a rotating offset inlet guide vane (IGV); a translating wave IGV; and a stationary uncambered IGV. All three configurations are operated in both the choked and unchoked modes for a range of airflows. The acoustic and aerodynamic performances are found to be dependent on the geometry of the test configurations. Choking in an uncambered IGV results in a noise reduction of 49 dB for the fundamental frequency. Choking in the offset IGV and in the wave IGV results in noise reductions of 21 dB and 34 dB, respectively. The total pressure recovery for the uncambered IGV is 0.94 out of 1.00, whereas total pressure recoveries in the choked mode for the offset IGV and the wave IGV are 0.57 and 0.66, respectively. N71-37601

72—577

COMMUNITY NOISE AND ENVIRONMENT CONTROL
Davis, H.H. (Univ. Adelaide, Australia)
J. Instn. Engr. (Australia) 43(10-11), 3-7 (Oct. 'Nov. 1971)

Key Words: environments, human, noise

This paper deals with one area of environmental pollution (noise) which extends throughout the community in any developed country.

72—578

NOISE IN THE ENVIRONMENT
Franken, P.A. and Page, D.G. (Bolt Beranek and Newman Inc., Cambridge, Mass.)
Envir. Sci. Tech. 3(2), 125-129 (Feb. 1972)

Key Words: noise (sound)

The noise pollution problem as it exists today is reviewed. Efforts to correct these ills are discussed.

72—579

LEGISLATIVE FACTORS OF NOISE -- MEETING THE OCCUPATIONAL NOISE REGULATIONS OF THE U.S. DEPARTMENT OF LABOR
Gidel, R.D. (Bu. Labor. Std., Workplace Std. Admin., U.S. Dept. Labor)
SAE Paper No. 700714 (Sept. 14-17, 1970)

Key Words: human, noise legislation

The limiting of noise and noise-related safety hazards in industry is discussed. There are presently four federal laws in effect, designed to protect occupational safety. A fifth law is being considered by Congress which, if passed, should provide additional noise control. The details of the U.S. Department of Labor regulations, such as sound levels, varied forms of noise, control measures, and protective equipment, are examined.

72—580

SCALES FOR ASSESSING THE NOISE ENVIRONMENT
Gordon, C.G. (Wolfson Unit for Noise and Vib. Control, Univ. Southampton, Southampton, England)
Engr. Matl. Design 14(11), p. 1107 (Dec. 1971)

Key Words: noise measurement

All the scales and schemes in current use for noise exposure assessment attempt to define the interaction of the person with his environment by a single number which may then be set against some derived scale of effect. Three categories of scale can be identified: single number scales which combine the level and frequency parameters of the physical environment alone; single number scales which combine the level, frequency and time characteristics of the physical environment alone; and single number rating procedures which introduce adjustments for various characteristics of the noise and of the situation into which the noise intrudes (for instance, corrections to account for pure tones, impulsive irregularities, type of neighborhood, time of day, etc.). The commonly used scales in each category are described.

72—581

FREEWAY AND HIGHWAY TRAFFIC NOISE: AN INFORMATION BASE FOR URBAN DEVELOPMENT DECISIONS
Lane, S.R. (School Architecture and Pla ning, Calif. Univ., Los Angeles, Calif.)
90 pp (Aug. 1971)

Key Words: noise generation, noise tolerance, traffic noise

In the 30 to 50 mi core area of Los Angeles, there are 350 mi of freeway which carry a million commuters daily and a high level of truck traffic. In general, freeway traffic causes almost continuous noise levels of 90 to 70 dBA, in the five block wide strips on either side of the freeways. This study analyzes the sources of this noise and its effects on human activity.
PB-204434

72—582

NOISE IN INDUSTRY
Monk, R.G. (Acoust. Tech. Ltd.)
Engr. Matl. Design 14(11), 1099-1101
(Dec. 1971) 4 refs

Key Words: industry, noise reduction

Noise pollution as a serious and widespread problem is examined. Ways in which industry can prepare itself to tackle the problem are suggested.

72—583

A GENERALIZED THEORY ON THE NOISE GENERATION FROM SUPERSONIC SHEAR LAYERS
Pao, S.P. (Wyle Labs., 7800 Governors Drive West, Huntsville, Ala.)
J. Sound and Vib. 19(4), 401-410
(Dec. 22, 1971) 14 refs

Key Words: noise generation

In 1960, O. M. Phillips introduced a theory on noise generation from supersonic shear layers. The theory is based on a convective wave equation which can describe the aerodynamic parameters and noise generation mechanism more accurately than the original Lighthill equation. The solution to the convective wave equation, as given by Phillips, is restricted to Mach wave radiation at asymptotically large (hypersonic) Mach numbers. The present paper presents a generalization to Phillips' theory. Both Mach wave radiation and non-Mach wave noise radiation mechanisms are considered. The range of validity of Phillips' theory is expanded to include the low supersonic and transonic ranges. This theory is considered to have the prospect of answering important questions in supersonic jet noise such as noise source distribution, mean flow refraction effects, directivity, spectrum, and efficiency of noise radiation.

72—584

THE EFFECT OF THE ACOUSTIC PROPERTIES OF THE ENVIRONMENT ON VIBRATION OF A FLAT PLATE SUBJECT TO DIRECT EXCITATION AND TO EXCITATION BY VORTEX SHEDDING IN AN AIRSTREAM
Parker, R. (Dept. Mech. Engr., Univ. Col. Swansea, Singleton Park, Swansea SA2 8PP, U.K.)
J. Sound and Vib. 20(1), 93-112
(Jan. 8, 1972) 7 refs

Key Words: acoustic excitation, aerodynamic excitation, plates, vibration response

The results of an experimental investigation of the vibration of a flat steel plate when excited by a magnetic vibration transducer and by wake shedding caused by air flow over the plate are presented. The acoustic properties of the space surrounding the plate, in particular the acoustic resonant frequencies, have a marked influence on the amplitude of vibration and a small influence on the resonant frequencies. The effects include variation of the plate response to a given excitation and variation of the magnitude of the exciting forces resulting from wake shedding. Qualitative explanations of the phenomena are deduced with the aid of numerical solutions for the acoustic field with the plate vibrating.

72—585

THE INTERPRETATION AND MEANING OF LABORATORY DETERMINATIONS OF THE EFFECT OF DURATION ON THE JUDGED ACCEPTABILITY OF NOISE
Parry, H.J. and Parry, J.K. (Lockheed-Calif. Co., Burbank, Calif.)
J. Sound and Vib. 20(1), 51-57
(Jan. 8, 1972) 21 refs

Key Words: noise tolerance

Laboratory determinations of the effect of duration on the judged acceptability of noises have produced conflicting, if not confusing, results. Further, there is the question of application of so-called duration corrections to the prediction of community response to vehicle noises. The laboratory experiments are reviewed in detail to provide a firm understanding of the present status of that data. This investigation develops the very strong implication that judging duration in terms of equivalent noise levels is, in reality,

a type of cross-modality experiment wherein the subject is simply measuring duration. There is some evidence that the community is concerned only with noises of different duration above the speech interference level.

72—586

INFLUENCE OF MASKING TONES AND NOISES ON THE PITCH OF A PURE TONE
Terhardt, E. and Fastl, H. (Institut für Elektroakustik der Technischen Universität München, Germany)
Acustica 25(1), 53-61 (July 1971) 15 refs

Key Words: noise

The pitch shift of a tone caused by superimposing a second tone or a band limited noise, both in close spectral vicinity of the tone, is investigated. The pitch shift is upward for all tone frequencies when the masking sound's frequency range is just below the frequency of the tone. With the masking sound just above the tone, the pitch shift is downward for tone frequencies below 500 Hz; higher tones under the same conditions exhibit either no systematic pitch shift or a small shift upward. (In German)

PERIODIC
(Also see No. 690)

RANDOM
(Also see Nos. 552, 749, 755)

SEISMIC
(Also see Nos. 563, 664, 689, 715, 716, 750)

SHOCK
(Also see Nos. 570, 602, 609, 642, 680, 708, 722, 723, 728, 752)

GENERAL WEAPON
(Also see Nos. 691, 747, 748)

72—587

INVESTIGATION OF AIR INDUCED GROUND SHOCK EFFECT RESULTING FROM VARIOUS EXPLOSIVE SOURCES -- REPORT 2: INFLUENCE OF CONSTITUTIVE MODELS ON GOUND MOTION PREDICTIONS
Baron, M. L.; Nelson, I.; and Sandler, I. (Paul Weidlinger, Consulting Engr., New York, N. Y.)
63 pp (Nov. 1971) 15 refs

Key Words: explosions, ground shock, mathematical models

In recent years, the development of mathematical models for the study of ground shock effects in soil and/or rock media has made important progress. Three basic types of advanced models are studied: (a) elastic-ideally plastic models, (b) variable moduli models, and (c) elastic-nonideally plastic capped models.

72—588

UNDERGROUND ENGINEERING APPLICATIONS, CONCEPTS, AND EXPERIENCE
Nordyke, M. D. (Lawrence Radiation Lab., Calif. Univ., Livermore, Calif.)
61 pp (Feb. 1971)

Key Words: nuclear explosions, underground explosions

Industrial applications of underground nuclear explosions are discussed. These applications include natural gas production stimulation, in-situ copper leaching, geothermal heat recovery, and excavation of deep underground radioactive waste repositories. Experience and data gained from the Gasbuggy and Rulison Events are examined in detail and evaluated.
NSA-51664

72—589

AIRBLAST FROM PROJECT TRINIDAD DETONATIONS
Vortman, L. J. (Sandia Labs., Albuquerque, New Mex.)
223 pp (June 1971)

Key Words: underground explosions

Airblasts measured from distances of a few hundred feet to about 6 mi from single 1 ton surface, near surface, and buried explosions are reported. Also, measurements made perpendicular to and off the ends of buried single-row charges detonated simultaneously and with delays between

charges in the rows, and buried double-row charges detonated simultaneously and with delays between rows are included. A 1 ton charge placed at the bottom of a 14 in. diam unstemmed hole produced overpressures and airblast energy about midway between an equivalent surface blast and a completely stemmed explosion at the same depth. Waveforms from all row charge detonations are complex, and neither peak overpressures nor positive impulses can be related consistently to those from single charges or to smaller buried TNT charges in a more uniform medium. No airblast damage occurred at either Jansen or Trinidad, Colorado, at a maximum peak overpressure of 0.009 psi.
NSA-51662

PHENOMENOLOGY

COMPOSITE
(Also see No. 565)

72—590

DYNAMIC MECHANICAL PROPERTIES OF SOME POLYSTYRENE COMPOSITES
Nielson, L.E. and Lee, B.L. (Monsanto Res. Corp., St. Louis, Mo.)
29 pp (Oct. 1971)

Key Words: mechanical properties, polystyrene composites

Dynamic shear modulus and damping are determined on polystyrene filled with glass beads which have been given surface treatments, ground glass, ground rock salt, and foams made by extracting the salt with water. Soaking the glass bead-filled polystyrene in water and then redrying produces a permanent increase in damping. Data on ground glass and on rock salt composites illustrate the importance of maximum packing volume on the modulus. It is shown that moduli determined by torsional tests or by flexural tests are in error because of a polymer-rich skin. A simple method is given for correcting this error.
AD-733462

DAMPING
(Also see No. 619)

72—591

THE FORCES ON A CYLINDER OSCILLATING SINUSOIDALLY IN WATER
Hamann, F.H. and Dalton, C. (Dept. Food Sci., Michigan State Univ., East Lansing, Mich.)
J. Engr. Indus., Trans. ASME 93 (4), 1197-1202 (Nov. 1971) 7 refs

Key Words: cylinders, offshore structures, underwater structures

The experimental modeling of wave forces on offshore structures is investigated. A sinusoidally oscillating cylinder in a body of water otherwise at rest is chosen as a model. Strain gages are used to measure the dynamic force generated by the water-cylinder interaction. Oscillations of amplitudes ranging from 0.67 to 9.6 cylinder diameters and frequencies from 10 to 60 Hz are covered. Diagrams of force vs velocity with acceleration as a parameter and of maximum force vs the amplitude parameter, A/d, are included.

72—592

STABILITY OF CIRCULATORY ELASTIC SYSTEMS IN THE PRESENCE OF MAGNETIC DAMPING
Smith, T.E. and Herrmann, G. (Evanston, Ill.)
Acta Mechanica 12 (3 '), 175-188 (1971) 9 refs

Key Words: elastic media, magnetic damping, stability

The effect of a type of magnetic damping upon the stability of some circulatory elastic systems is examined and the results are compared with those obtained for internal and external viscous damping. Differences and similarities are discussed.

72—593

DETERMINATION OF THE ENERGY DISSIPATION IN MATERIALS ASSOCIATED WITH STEADY STATE RESONANCE OSCILLATIONS
Tyulenev, V.N.
(Trznsl. Sb. State, Prochnosti i Dinam. Aviats. Dvigatelei 5, 169-193 (1969), USSR); 47 pp (May 26, 1971)

Key Words: material damping, periodic response, testing techniques

A description is given of a method of studying the damping properties of machine element materials during tests on an electrodynamic

vibrator. Energy dissipation can be determined by this method in specimens of materials and various vibration modes produced by the electrodynamic vibrator. The method is based on the determination of the energy absorption coefficient represented by a ratio of the energy dissipated in the element during one vibration cycle to maximum potential energy. This coefficient is obtained by measuring the ratio between the vibration amplitudes of the electrodynamic vibrator platform and the displacement amplitudes of a point on the specimen. The method is applied to steel and titanium specimens and to glass fiber reinforced plastic materials.
AD-727458

72—594

DRAG OR ALONG-WIND RESPONSE OF SLENDER STRUCTURES
Vickery, B.J. and Kao, K.H.
J. Struc. Div., Proc. ASCE 98ST1), 21-36
(Jan. 1972) 11 refs

Key Words: aerodynamic excitation, chimneys

Theoretical approaches to the evaluation of the response of slender structures in turbulent shear flow proposed by a number of researchers are reviewed and examined in the light of recent experimental results. Theories are applied to predict the response of a slender tapered stack of circular cross section and the predictions are compared with experimental observations of the behavior of a model stack in boundary layer flow. It is demonstrated that quasi-steady approximations are adequate for wavelengths greater than about 5 to 10 times the width of the structure and that the extension of the quasi-steady approach to shorter wavelengths will, in general, yield a small overestimate of response. It is also shown that estimates of aerodynamic damping based on quasi-steady assumptions are adequate.

72—595

EVALUATION OF ORTHOGONAL DAMPING MATRICES
Wilson, E.L. and Penzien, J. (Univ. Calif., Berkeley, Calif.)
Intl. J. Numer. Methods Engr. 4, 5-10
(Jan.-Feb. 1972) 1 ref

Key Words: modal damping, matrix methods, viscous damping

Two methods for the numerical evaluation of orthogonal damping maxtrixes are presented. One relates the modal damping ratios to the coefficients of the Caughey series; the other is a direct approach which expresses the damping matrix as a sum of a series of matrixes each of which produces damping in a particular mode. The direct approach is more convenient to apply and is less numerically sensitive than the series approach.

72—596

DAMPING SOURCES IN WOOD STRUCTURES
Yeh, C.T.; Hartz, B.J.; and Brown, C.B.
(Taiwan Area Freeway Construction Bu., Republic of China)
J. Sound and Vib. 19(4), 411-419
(Dec. 22, 1971) 12 refs

Key Words: buildings, material damping

Damping in wood structures is either associated with the material itself or with the joining devices. An experimental study indicates that material damping is relatively independent of wood type and constant in a given environment. Nailed joints can provide additional damping which can be further augmented by special nailing devices. Such devices increase the total damping by more than an order of magnitude. The damping of glued joints depends upon the characteristics of the adhesive. The adhesive can double the damping provided by the wood alone.

72—597

THE PREDICTION OF DAMPING IN NAILED AND GLUED WOOD STRUCTURES
Yeh, C.T.; Hartz, B.J.; and Brown, C.B.
(Taiwan Area Freeway Construction Bu., Republic of China)
J. Sound and Vib. 19(4), 421-435
(Dec. 22, 1971) 4 refs

Key Words: material damping, prediction, structural members

Improvement of damping of small amplitude vibrations can be obtained by properly optimizing glued and nailed joints. In this paper methods for accurately predicting such damping are developed which require simple tests on small specimens. The analytical predictions are confirmed by experiments on structural members. These results can lead to arrangements of joints which maximize the damping.

ELASTIC
(Also see No. 540)

72—598

DYNAMIC AND STATIC RESPONSE IN A TRANSVERSELY ISOTROPIC MEDIUM
Freedman, J.M.
80 pp (1971)

Key Words: dynamic response, transversely isotropic media

Plane dynamic and static contact stress problems are treated. An elastic transversely isotropic material representation is used and the analysis herein is also applicable for layered materials. The analyses show that techniques applicable to isotropic elastic contact problems are also, after some modification, applicable to anisotropic problems. Numerical results indicate that substantial differences between anisotropic and isotropic response may occur; however, elastic constants for both situations must be completely specified if a meaningful comparison is to be made.
UM 71-30,803

72—599

AN EXPERIMENTAL AND THEORETICAL INVESTIGATION OF ELASTIC WAVE PROPAGATION IN A CYLINDER
Zemanek, J., Jr. (Dept. Phys., Univ. Calif., Los Angeles, Calif.)
J. Acoust. Soc. Am. 51(1), 265-283 (Jan. 1972) 21 refs

Key Words; cylindrical shells, elastic waves, wave propagation

The problem of wave propagation in an isotropic elastic cylinder is investigated with the aid of a high speed computer. Dispersion curves are given corresponding to real, imaginary, and complex propagation constants for the symmetric and the first four antisymmetric modes of propagation. The radial distributions of axial and radial displacements and of shear and normal stresses are included for the symmetric mode. An approximate solution is found for the problem of the L(0,1) mode impinging on a traction free interface. The reflection coefficient is determined and the accompanying generation of higher order modes at the interface is shown to cause a high-amplitude end resonance. Experimental results obtained are presented to substantiate the calculated reflection coefficient and the frequency of end resonance. Phase velocities are obtained for the symmetric and first two antisymmetric modes. The root mean square deviation between theoretical and experimental results is in general less than 0.2 percent, the exception being the dispersion curve for the L(0,2) mode which is 0.7 percent.

FLUID
(Also see Nos. 545, 591, 612, 646, 648, 652, 661, 670, 675, 717, 729, 752)

72—600

ACOUSTIC WAVE PROPAGATION IN A BINARY MIXTURE OF INVISCID FLUIDS
Craine, R.E. and Johnson, A.F. (Dept. Math., Univ. Southampton, Southampton SO9 5NH, England)
J. Sound and Vib. 20(2), 191-207 (Jan. 22, 1972) 16 refs

Key Words: fluids, sound waves, wave propagation

Linearized equations governing the thermomechanical behavior of a binary mixture of inviscid fluids are derived. Restrictions which are sufficient for the equations to have a unique solution are imposed on some of the material constants. The propagation of plane harmonic waves of small amplitude in the mixture is examined and the inequalities are shown to ensure a physically reasonable response. As an application of the theory properties of acoustic waves in a binary mixture of ideal gases are evaluated numerically.

72—601

ESSENTIAL CONSIDERATIONS INVOLVED IN HYDRAULIC COMPONENT NOISE
McBurnett, J.R.; Fitch, E.C., Jr.; and Lowery, R.L. (School Mech. Aerosp. Engr., Okla. State Univ.)
SAE Paper No. 700712, (Sept. 14-17, 1970) 36 refs

Key Words: hydraulic systems, machinery, noise reduction

A comprehensive treatment of the essential considerations involved in measuring the noise generating characteristics of hydraulic components is presented. The need for the reduction of noise levels for all types of hydraulic machinery is discussed from the manufacturer's point of view. The mechanical and fluid dynamic aspects associated with hydraulic components which create undesirable and damaging noise levels are described. Special emphasis is placed on quantitative methods for establishing

and comparing noise levels of operating hydraulic components. A cursory review of the necessary facility requirements and measuring techniques is included.

72—602

A SOLUTION OF SHOCK-INDUCED BOUNDARY-LAYER INTERACTION PROBLEMS BY AN INTEGRAL METHOD
Murdock, J.W. (Tech. Div., Aerosp. Corp., San Bernardino, Calif.)
J. Appl. Mech., Trans. ASME 38 (4), 775-782 (Dec. 1971) 7 refs

Key Words: boundary layer excitation, integral method, shock excitation

An integral technique developed to solve a general class of shock-induced boundary-layer interaction problems is presented. The boundary layer which grows downstream of the leading edge of a semi-infinite flat plate with a shock wave propagating over it is included, and the boundary-layer region in a shock tube that is dependent upon both the shock wave and the expansion wave. The integral equations used to solve the Howarth transformed (incompressible) momentum equation are formulated. The solutions generated are in excellent agreement with published exact solutions. All discontinuities in the slope of the shear stress present in earlier similar integral solutions are eliminated. The predicted momentum and displacement thicknesses and the wall shear stress are within 1 percent of the exact values.

INELASTIC
(Also see No. 631)

SOIL

72—603

INFLUENCE OF DYNAMIC LOADING, BIAXIAL LOADING, AND PREFRACTURING ON THE STRESS-STRAIN AND FRACTURE CHARACTERISTICS OF ROCKS
Brown, W.S.; Swanson, S.R.; and Wawersik, W.R. (Univ. Utah, Salt Lake City, Utah)
120 pp (Mar. 15, 1971) 50 refs

Key Words: dynamic testing, experimental results, fracture properties, rocks, testing techniques

Stress-strain and fracture data for rocks under a variety of loading conditions are presented. Strain rate effects and biaxial loading conditions are included. Complete strain histories are obtained for precracked rock specimens. Descriptions of the appratus and test methods and experimental results are included.

72—604

SUBSIDENCE OF SAND DUE TO SURFACE VIBRATION
Brumund, W.F. and Leonards, G.A.
J. Soil Mech. Foundations Div., Proc. ASCE 98 (SM1), 27-42 (Jan. 1972) 33 refs

Key Words: sands, vibratory compacting

Laboratory tests conducted using a plate type vibrator on the surface of a sand sample are reported. The static weight, dynamic force, and frequency of the vibrator are independently varied and the resulting contact force, acceleration, amplitude of vibration, and residual settlement are measured. Results show that the parameter that governs the surface settlement of a vibrating footing on a granular mass is the steady state transmitted energy. This is true for a wide range of frequencies both above and below resonance and for large variations in the ratio of the dynamic force to static weight, provided this ratio is less than unity and the total transmitted force does not exceed the static failure load. In general, the surface settlement cannot be correlated to acceleration only. The transmitted energy may also be a key factor in the design of efficient vibratory compaction equipment.

72—605

PARAMETERS REQUIRED TO SIMULATE THE DYNAMIC LATERAL RESPONSE OF MODEL PILES IN SAND
Wright, D.A. and Coyle, H.M. (Dept. Civil Engr., Tex. A & M Univ., Col. Station, Tex.)
94 pp (Aug. 1971)

Key Words: computer programs, dynamic response, pile structures

Three instrumented model piles of varying diameters and embedded lengths are driven into sand and field tested laterally under free vibration conditions. The dynamic response of each model pile as measured in the field is reported. Bending moment and acceleration vs time data are obtained. An analytical computer solution is used to predict the response of the model piles. A modified Voight-Kelvin theological model is utilized in the analytical computer solution to model the nonlinear load-displacement characteristics of the soil. The predicted response

of the model piles is correlated with the measured field data. Using these correlations and laboratory data obtained from tests on soil samples taken at the test site, the soil parameters required to simulate the dynamic field response of the model piles are evaluated.

THERMOELASTIC

(Also see Nos. 556, 607, 640)

72—606

COUPLED THERMOELASTIC VIBRATIONS OF BEAMS
Seibert, A.G.
259 pp (1971)

Key Words: beams, coupled response, thermoelasticity

Biot's quasi-variational principle of coupled thermoelasticity is used as a computational scheme to generate the basic coupled thermoelastic partial differential equations and boundary conditions of Rayleigh and Timoshenko beams. A linear law for entropy displacement is found which yields partial differential equations derived by Jones directly from the equations of three-dimensional coupled thermoelasticity. The resulting equations are modified to permit application to beams with heat flux input to their lateral sides. The derived equations are applied to examine the effect of the coupling term in the energy equation using several simple new problems of coupled thermoelastic vibrations, extending the work of Jones. The problem of free coupled longitudinal vibrations of the infinite beam is solved by approximating the roots of the secular equation by a first-order perturbation series of the thermoelastic coupling term. Similarly, solutions are obtained for the free coupled flexural vibrations of infinite Bernoulli-Euler and Timoshenko beams, and for a finite Timoshenko beam with pinned isothermal ends. Formal solutions are presented for forced coupled flexural vibrations of a semi-infinite Bernoulli-Euler beam with one pinned isothermal end, and for Bernoulli-Euler and Timoshenko beams with pinned isothermal ends. The equations are also applied to the solution of the problem of thermally induced thermoelastically coupled vibrations. It is concluded that Biot's quasi-variational principle of coupled thermoelasticity when used with the entropy displacement laws presented here results in the correct fundamental field equations for Rayleigh and Timoshenko beams.
UM 72-1211

72—607

THERMOELASTIC DAMPING AND ITS EFFECT ON FLUTTER OF STRESSED PANELS SITUATED IN A SUPERSONIC AIRFLOW
Shieh, R.C. (NASA-Langley Res. Ctr., Hampton, Va.)
NASA-TN-D-6448, 32 pp (Nov. 1971)

Key Words: flutter, material damping, rectangular panels

The effects of material damping on flutter of stressed rectangular panels are studied within the context of linear thermoelasticity theory. The closed-form expression for the thermoelastic (material) damping coefficient is obtained as a function of frequency, panel temperature and dimensions and material properties. The solution of the stability boundary value problem is obtained by use of a generalized Galerkin method in the cross-stream direction which reduces the governing partial differential equations to a system of ordinary differential equations in the streamwise direction. These equations are then solved. Numerical results are given for the flutter speeds of partially and fully clamped panels subjected to midplane stress.
N72-10958

VISCOELASTIC

(Also see No. 556)

EXPERIMENTATION

DIAGNOSTICS

(Also see Nos. 619, 743)

72—608

DRILL-STRING VIBRATIONS GIVE INSTANTANEOUS FORMATION LOG
Oil and Gas J. 69(45), p 62 (Nov. 8, 1971)

Key Words: diagnostics, drilling, vibratory tools

A fresh approach to instantaneous logging while drilling is made on the basis of drill-string vibrations. This dynamic measurement could provide formation data of value in choosing bits and in evaluating drilling performance. The instantaneous nature of the method makes it interesting as an approach to improving the accuracy of optimum drilling techniques.

EQUIPMENT
(Also see Nos. 615, 621)

72—609
APPARATUS FOR IMPACT-FATIGUE TESTING
Schramm, R.E.; Durcholz, R.L.; and Reed, R.P. (Cryogenics Div., Natl. Bu. Std., Boulder, Colo.)
J. Res. Natl. Bu. Sta. 75C (2), 95-98 (Apr./June 1971)

Key Words: impact tests, test equipment

A standard impact machine was extensively modified to allow the measurement of the response of specimens to repeated, controlled impact pulses. This equipment enables one to vary the temperature (76-297 K), specimen geometry (uniaxial, biaxial, triaxial stress systems), and load levels. At stress levels in the neighborhood of the yield stress, on the order of 10,000 impact cycles are needed to fatigue specimens to fracture. Strain rates achieved are moderately high, of the order of 1000 min^{-1}, which conveniently form intermediate data between tensile (max. of about 100 min^{-1}) and explosive straining data (about 6000 min^{-1}). Contrasted to standard fatigue tests no constraint is placed on specimen elongation and only unidirectional stresses are imposed. Typical impact-fatigue results for AISI 310 stainless steel are presented.

72—610
UNUSUAL APPLICATIONS OF VIDEOTAPE RECORDERS
Reis, J.J. (Northrop Corp. Labs.)
Res. Dev. 23 (2), 24-26 (Feb. 1972)

Key Words: data recording, videotape

Videotape recording, commonly known as a television "instant replay" device, is being used as a tool for experiments. The versatile videotape recorder has demonstrated capabilities in high-technology data gathering applications, in addition to more conventional employment in training classes and management communications. This article concentrates on the use of the helical scan videotape recorder as a laboratory tool, showing how its bandwidth of up to 4.2 MHz and its capability of producing slow motion and freeze frame images have been used. In addition, modifications of commercial units for laboratory use are discussed.

EXPERIMENT DESIGN
(Also see Nos. 618, 697, 746)

INSTRUMENTATION
(Also see No. 619)

72—611
DOUBLE-FREQUENCY STROBOSCOPIC METHOD FOR ABSOLUTE CALIBRATION OF VIBRATION TRANSDUCERS
Baggia, S. (Istituto di Metrologia "G. Colonnetti", Turin, Italy)
J. Sound and Vib. 20 (1), 59-69 (Jan. 8, 1972)

Key Words: calibrating, measuring instruments, transducers, vibration measurement

A new stroboscopic technique is described for a more accurate optical determination of vibration amplitude for the purpose of calibrating vibration transducers; the apparatus is composed of standard equipment which has been adapted to purpose-developed circuitry. A general analysis of the errors involved shows that a higher accuracy than that of other techniques can be obtained in the low frequency range (20-200 Hz). Consistent experimental data for a commercial crystal accelerometer and a standard velocity coil are also given together with some comments and conclusions about the accuracy obtained.

72—612
PERFORMANCE DEGRADATION OF DEEP-OCEAN TRANSDUCERS USING ONIONSKIN PAPER FOR ACOUSTIC DECOUPLING
Haan, D.E.; Higgs, R.W.; and Eriksson, L.J. (Honeywell Marine Syst. Ctr., Seattle, Wash.)
J. Acoust. Soc. Am. 51 (1), 290-294 (1972) 10 refs

Key Words: transducers, underwater sound

The acoustic decoupling behavior of onionskin paper is examined. Emphasis is placed on sonar transducer applications. Nonlinear changes in the sound velocity of onionskin paper with pressure predict the degradation of both frequency and directional response. Results are obtained by computer analysis of a longitudinal-vibrator equivalent circuit and are in reasonable agreement with the measured characteristics of a specific transducer configuration.

PROCEDURES

72—613

THE SINGLE-PULSE METHOD FOR MEASURING THE TRANSMISSION CHARACTERISTICS OF ACOUSTIC SYSTEMS
Louden, M.M. (Univ. Libya, Tripoli, Libya)
Acustica 25(3), 167-172 (Sept. 1971) 9 refs

Key Words: pulse test method

A method to measure the transmission characteristics of acoustic systems with the help of a single pulse is presented. Through Fourier analysis of both the input and output pulses to the system, its transmission characteristics are determined in amplitude and in phase. The method is applied to measure the end correction of open pipes, the conductivity of a side-hole in a pipe, and the transmission loss of partitions.

SCALING AND MODELING

(Also see Nos. 622, 692, 714)

72—614

AN INVESTIGATION OF SCALING LAWS FOR VIBRATING BEAMS AND PLATES WITH SPECIAL ATTENTION TO THE EFFECTS OF SHEAR AND ROTATORY INERTIA
Kristiansen, U.R.; Soedel, W.; and Hamilton, J.F. (Inst. Sound and Vib. Res., Univ. Southampton, Southampton SO9 5NH, England)
J. Sound and Vib. 20(1), 113-122 (Jan. 8, 1971; 9 refs

Key Words: beams, natural frequencies, plates, secondary effects, simulation

Scaling laws for vibrating beams and plates are investigated. It is shown how scaling laws can be derived directly from the equations of motion by nondimensionalizing the variables. The scaling laws obtained from the classical equations (Bernoulli-Euler's beam and Lagrange's plate equations) are nonrestrictive in the sense that they allow for independent scaling of the system variables. The laws obtained from the advanced equations (Timoshenko's beam and Mindlin-Reissner-Uflyand's plate equation) are identical with the Newtonian scaling requirements. The nonrestrictive plate scaling law is applied in an experimental study to predict natural frequencies of a plate from the measured natural frequencies of a model. Nonrestrictive laws incorporating the effects of shear and rotatory inertia can be obtained by using the classical theory scaling laws together with approximate compensation factors obtained by assuming that, at higher modes, the compensation factors obtained for simply supported systems are applicable to systems having other boundary conditions.

TECHNIQUES

(Also see Nos. 590, 603, 692, 703, 707, 708)

72—615

MULTIPOINT EXCITATION TECHNIQUES
Anderson, D. and Mills, B.
Envir. Engr. 51, 12-16 (Dec. 1971) 3 refs

Key Words: resonance tests, testing techniques

This paper describes the advantages of using multipoint excitation for producing resonance of complex structures and presents some practical results of tests carried out on a motor car subassembly.

72—616

NONDESTRUCTIVE TESTING OF CONCRETE
Burt, J.O., Jr. and Rushing, H.B. (R & D Section, La. Dept. Highways)
20 pp (Nov. 1970)

Key Words: concrete, nondestructive tests, test equipment, ultrasonic testing

The performance of an ultrasonic testing device used to predict compressive strengths from tests performed on samples of fresh concrete is evaluated. Concrete cylinders possessing various water cement ratios are tested using ultrasonic equipment. The results are not encouraging. Very little predictability of compressive strength on sand and gravel mixes is possible until several hours after addition of water to the mixes. Experimentation with more homogeneous sand mixes yields no better results. Further investigation with the present available equipment seems unwarranted.
PB-204372

72—617

VIBRATION TESTS WITH THE SNAP-8 CONDENSER P/N 093945-1, S/N A-1
Chalpin, E.S. and Lombard, G.L. (Power Syst. Div., Aerojet-Gen. Corp., Azusa, Calif.)
NASA-CR-72925, 84 pp (Apr. 21, 1970)

Key Words: missile launchers, shock testing, vibration tests

The SNAP 8 condenser consists of 73 tapered 9 percent chromium, 1 percent molybdenum steel

tubes contained in a stainless steel shell. Mercury vapor enters the larger end of the condenser and flows through the tapered tubes while NaK, flowing counter to the mercury, passes through the space within the shell and around the tube bundle. During normal operation, the condenser is in the vertical position with the mercury vapor end up. Environmental testing is done to evaluate the basic structural design at conditions that are expected during a vehicle launch and/or landing and maneuvering mode in space. The NaK inlet and outlet ports are removed at 1 and 1 1/2 in. from the manifolds. The NaK fluid is simulated during vibration testing with an oil which has a density and viscosity at room temperature close to that of NaK at 600°F. The mercury side is not filled since it is normally empty during launch. Sinusoidal, random, and shock tests are performed along three mutually perpendicular axes.
N71-38706

72—618

PHOTOELASTIC INVESTIGATION ON THE CRACK-ARREST CAPABILITY OF A HOLE
Kobayashi, A.S.; Wade; B.G.; and Maiden, D.E. (Mech. Engr. Dept., Univ. Wash., Seattle, Wash.)
Experimental Mech. 12(1), 32-37 (Jan. 1972) 9 refs

Key Words: crack propagation, dynamic photoelasticity

Dynamic photoelasticity employing a 16-spark gap Cranz-Schardin camera system is used to determine certain conditions leading to fracture arrest by a circular hole ahead of a propagating crack. Photoelastic models of 3/8 x 10 x 10 in. Homalite-100 plates with a 1/2 in. edge crack are loaded in a fixed-grip configuration and crack arrest is made possible by central holes of 1/2, 1/4, and 0.15 in. diam. In one test of 0.15 in. diam, the propagating crack continued through this hole. Changes in dynamic-stress-intensity factors, as the crack tip approaches the hole, and changes in the dynamic-stress-concentration factors at the far side of the hole are studied. These results are compared with the corresponding static results determined by finite element analysis. This comparison shows that the static analysis can be used to qualitatively assess the arrest capability of the hole using the maximum static-stress concept, or the proposed concept of strain energy released as the crack penetrates the hole.

72—619

THE RECONSTRUCTION OF ELASTIC WAVE FIELDS FROM MEASUREMENTS OVER A TRANSDUCER ARRAY
Maginness, M.G. (Stanford Elec. Labs., Stanford Univ., Stanford, Calif.)
J. South and Vib. 20(2), 219-240 (Jan. 22, 1972) 28 refs

Key Words: field reconstruction, ultrasonic imaging, wave propagation

The general problem of constructing complete information about a field in an isotropic elastic medium when knowledge is confined to measurements of field components over a single surface is discussed with particular reference to an ultrasonic imaging system development. It is shown that by suitable decomposition of the observed distribution into plane waves, a description of the field valid at any distance from the measuring surface may be derived in a form particularly suited to numerical calculation. Under practical constraints on the complexity of the field and when only longitudinal waves are used in the imaging process, measurement of only one component of particle displacement is sufficient to completely characterize the field. The formulations are extended to include wide bandwidth insonification and exhibit the reconstruction relationships in an alternative form involving the superposition of spherical waves. The spherical and plane waveforms are shown to be expressible as a multidimensional convolution or as a transform domain equivalent respectively. Some experimental results computed from actual measured fields are presented.

72—620

DETERMINATION OF FIXED-BASE NATURAL FREQUENCY OF MULTIPLE FOUNDATION MECHANICAL SYSTEMS BY SHAKE TEST
Ni, C.C. and Skop, R.A. (Naval Res. Lab., Washington, D.C.)
39 pp (Nov. 17, 1971)

Key Words: natural frequency, shipboard equipment response, vibration tests

Simple cases analyzed for a one-dimensional linear chain, and for duel-foundation shipboard equipment are presented. The report includes the analytical presentation of this method, the physical interpretation of the entities derived, the technical method suggested in taking and analyzing test data and drawing conclusions, and the extension of its application to damped systems. Various computer simulations of a problem designed to illustrate the developed method are provided.
AD-733654

72-621

UTILIZATION OF RESONANT FIXTURES TO ATTAIN HIGH AMPLITUDES IN SHOCK SYNTHESIS TESTING
Robbins, C.D. and Vaughan, P.E. (Dallas Baptist Col.)
SAE Paper No. 700848 (Oct. 5-9, 1970) 7 refs

Key Words: test equipment, vibrators (Machinery), vibration tests

Advances made in the application of electrodynamic vibration exciters for performing shock tests specified in terms of the response spectrum are discussed. Instrumentation available to synthesize and control a shock excitation that has the desired shock spectrum is reviewed. Some test specifications, especially those pertaining to pyrotechnic environments, require very high-shock spectrum amplitudes, some as high as 10,000 g. These high levels exceed the capability of most vibration exciters, particularly for large test loads. Resonant fixtures can be used to attain high-shock response amplitudes over the entire frequency range of interest in shock synthesis testing with vibration exciters.

72-622

APPLICATION OF IMPACT TESTING TO LID-FIXING SCREWS OF IRRADIATED FUEL FLASKS
Williamson, S. (U.K. Atomic Energy Authority, Risley, England)
From Seminar Tests on Transport Packaging for Radioactive Materials, Vienna, Austria, (Feb. 8, 1971) 16 pp

Key Words: drop tests, fasteners, impact tests

Drop tests performed on scale models of irradiated fuel flasks indicate that scaling comparisons cannot readily be made of the effect of impacts on the lid-fixing screws. A series of impact tests performed to examine the effect of dynamic tensile loading on single screws of different sizes is reported. A range of screws from the Excellox and Magnox irradiated fuel flasks (1/16, 1/4 and full-scale) are tested. Each screw is set up with a known weight fitted under the head and tightened to a known torque. The assembly is dropped so that the weight stretches the screw shank. Examination of the permanent extension that occurs suggests that within the limits of the equipment used, the percentage extension of screws at different scales is approximately constant and, therefore, linear scaling can be accepted.
NSA 51941

COMPONENTS

ABSORBERS
(Also see Nos. 704, 719, 725)

BEAMS, STRINGS, RODS
(Also see Nos. 548, 561, 562, 564, 606, 608, 737)

72-623

DYNAMICS OF THE PIANOFORTE STRING AND HAMMER
Deb, K.K. (Dept. Phys., Suri Vidyasagar Col., Suri, Birbhum, West Bengal, India)
J. Sound and Vib. 20(1), 1-7 (Jan. 8, 1972) 11 refs

Key Words: flexural vibration, musical instruments, string

The dynamics of the transverse vibration of a string fixed at both ends and excited by the transverse impact of a hard load at any point are worked out using an operational method for Heaviside's expansion theorem. The analysis includes the loading of the string by the hammer during the period of contact. Expressions are obtained for the displacement at the point struck and for the force exerted by the string on the hammer during the period of contact. Values calculated from these expressions are compared with values obtained experimentally by M. Ghosh, with excellent agreement.

72-624

NORMAL MODE SOLUTION FOR THE VIBRATIONAL MOTIONS OF LONG FLEXIBLE BOOMS ON THE RAE SATELLITE
England, F.E. and Cunniff, P.F. (Westinghouse Def. Space Ctr., Friendship Intl. Airport, Baltimore, Md.)
J. Engr. Indus. Trans. ASME 93(4), 1280-1289 (Nov. 1971) 16 refs

Key Words: antennas, booms, natural frequencies, periodic response

A normal mode analysis is applied to the Radio Astronomy Explorer satellite. The satellite uses four 750 ft booms arranged in an X configuration. The state variables consist of three Euler angles of the central body, a damper boom angle and an 8n generalized coordinate for the four booms, in two orthogonal directions each, for each of the n normal modes selected. The following information is obtained: the static deflection of

the antenna booms, the natural frequencies of the configuration, and the steady-state dynamic deflections of the booms caused by thermal bending. Results are compared with other approaches.

72—625

DYNAMICS OF A BEAM ON A NONLINEAR ELASTIC FOUNDATION
Fong, H.S. (Univ. S. Calif.)
272 pp (1971)

Key Words: beam, dynamic response, elastic foundation

The dynamic motion of a beam on a nonlinear foundation under a variety of conditions is studied. For the force-free case, it is shown that principal modes for this system can exist under certain conditions. In particular, when the nonlinearity (in the elastic modulus of the foundation) is polynomial in form, it is shown that principal modes exist only for odd-powered polynomials. The analysis reveals that the nonlinear mode shapes are distorted sinusoids and the nonlinear modal frequencies are amplitude-dependent, as opposed to being amplitude independent for a linear system. Two other force-free cases are studied in the same closed-form fashion: a piecewise linear approximation to the nonlinear foundation and the more physically realistic tensionless nonlinear foundation. The response of a beam on a nonlinear elastic foundation under a forced loading is also studied and a method to determine the response of the beam to transient excitation is formulated.
UM 72-3773

72—626

BEHAVIOR OF CROSSED BEAMS ON ELASTIC FOUNDATIONS
Glassman, A.
J. Soil Mech. Foundations Div., Proc. ASCE 98 (SM1), 1-11 (Jan. 1972) 8 refs

Key Words: beams, elastic foundations

A modified method of calculating crossed beams on elastic foundations is described. This method is based on the Zemozkin-Sinicyn theory assuming the soil to be an elastic, isotropic medium of infinite dimensions. Instead of solving the crossed beam as a unit, and thus dealing with numerous simultaneous linear equations, a method of separation of the two beams is presented. This method overcomes the problem of the discontinuity of the contact pressures under the intersection of the two beams, while combining them.

72—627

AXISYMMETRIC VIBRATIONS OF A FREE FINITE-LENGTH ROD
Hutchinson, J.R. (Dept. Civil Engr., Univ. Calif., Davis, Calif.)
J. Acoust. Soc. Am. 51 (1), 233-240 (Jan. 1972) 7 refs

Key Words: axisymmetric vibrations, rods

The axisymmetric vibrational characteristics of an elastic circular rod of finite length with stress-free boundaries are analytically determined. Comparison is made with approximate solutions. A series of functions are used which term-by-term satisfy the governing equations and the boundary conditions on the shear stress. The boundary conditions on the axial and radial stress are satisfied by an orthogonalization procedure which yields an infinite eigenvalue matrix, the coefficients of which are transcendental functions of the frequency. The procedure converges and sufficient accuracy is achieved, with truncation of a 20 x 20 eigenvalue matrix. These results are compared with the Pochhammer-Chree solutions which do not permit satisfaction of the boundary conditions on the ends of the rod. Comparisons are also made with the lowest mode of the free-plate solution, the plane stress solution for very short rods, and the one-dimensional rod solution for long rods.

72—628

SMALL-PERTURBATION ANALYSIS OF OSCILLATORY TOW-CABLE MOTION
Kerney, K.P. (Naval Ship R&D Ctr., Bethesda, Md.)
50 pp (Nov. 1971)

Key Words: cables (ropes), computer programs, oscillations

The equations of two-dimensional motion of a flexible inextensible cable are linearized by a small-perturbation approximation and sinusoidal time dependence is assumed. The simplified equations are integrated numerically by the Kutta-Merson method. Separate computer programs, OMWAY and OMFLO, written for the Quadrant 1 and Quadrant 2 cable-towed-body problems, are listed in the appendixes.
AD-733676

72—629

AXIALLY SYMMETRIC TRANSIENT WAVE PROPAGATION IN ELASTIC RODS WITH NONUNIFORM SECTION

Lee, P.C.Y. and Wang, Y.S. (Grumman Aerosp. Corp., Bethpage, N.Y.)

51 pp (Sept. 1971)

Key Words: method of characteristics, rods, shock excitation, variable cross section, wave propagation

A one-dimensional approximate theory is derived for an elastic circular rod with nonuniform cross section. Three coupled equations, taking into account the longitudinal, radial, and axial shear deformations and their inertias, are obtained as an extension of the Mindlin-McNiven theory to the case of nonuniform rods. Responses of both the semi-infinite rod and finite rod with elastic end support due to either a step or a pulse loading are studied by the method of characteristics. Calculated results such as stresses vs time for different stations along the rod and stresses as functions of distance for instants of time are presented and compared for several cases. The geometrical effect of the variation of section on the stresses and velocities and the effect of the elastic support on the reflection and propagation of the stress waves are deduced.

N71-38708

72—630

DYNAMIC STABILITY OF A BEAM CARRYING MOVING MASSES

Nelson, H.D. and Conover, R.A. (Dept. Engr. Mech., Arizona State Univ., Tempe, Ariz.)

J. Appl. Mech. Trans. ASME 38(4), 1003-1006 (Dec. 1971) 9 refs

Key Words: beams, dynamic stability, elastic foundations, moving loads

The lateral response of a simply-supported Bernoulli-Euler beam carrying a continuous series of equally spaced mass particles is analyzed for dynamic stability. The beam rests on a uniform elastic foundation. Damping is considered by including a distributed viscous damping coefficient and the particles are restricted to constant speed. A set of approximate governing equations of motion possessing periodic coefficients is generated using the Galerkin method. The parametric regions of stability, which are displayed in graphical form, are studied using Floquet theory.

72—631

NORMAL IMPACT OF AN INFINITE ELASTIC-PLASTIC BEAM BY A SEMI-INFINITE ELASTIC ROD

Ranganath, S. and Clifton, R.J. (Div. Engr., Brown Univ., Providence, R.I.)

Intl. J. Solids Struc. 8(1), 41-67 (Jan. 1972) 25 refs

Key Words: beams, secondary effects, shock excitation

Solutions are obtained for the problem of normal impact of an infinite elastic-plastic beam by a semi-infinite elastic rod. The effects of rotatory inertia and shear deformations are included in the equations governing the motion of the beam. A strain rate independent model based on concepts similar to those employed in quasi-static plasticity is used to describe material behavior. The interaction between moment and shear force is included. A strain hardening criterion is used based on the quasi-static moment-curvature relation for pure bending. Strain-time profiles computed using this theory agree reasonably well with those obtained in experiments on aluminum beams. The computed solutions are compared with predictions based on a rigid perfectly plastic beam theory.

72—632

ON THE OSCILLATORY MOTIONS OF TRANSLATING ELASTIC CABLES

Simpson, A. (Dept. Aeronaut. Engr., Univ. Bristol, Bristol BS8 1TR, England)

J. Sound and Vib. 20(2), 177-189 (Jan. 22, 1972) 8 refs

Key Words: cables, catenaries, equations of motion, mode shapes, natural frequencies

The equations of in-plane motion for an elastic catenary translating uniformly between its end supports are derived in what is, essentially, an Eulerian frame of reference. Approximate equations are analytically solved for the case where the catenary is shallow and the tension is dominated by the cable section modulus. Computed solutions for the natural frequencies and modes of a catenary of sag-span ratio 1:20 are presented and the modal characteristics are shown to be of an unusual form involving phase disparities from point-to-point on the cable as the cable oscillates at a natural frequency.

72—633

VIBRATION ATTENUATION WITH BEAMS -- THEORY AND RECIPROCAL EXPERIMENT
Snowdon, J.C. and Kerlin, R.L. (Ordnance Res. Lab., Pa. State Univ., Univ. Park, Pa.)
J. Acoust. Soc. Am. 51(1), 243-264 (Jan. 1972) 6 refs

Key Words: cantilever beams, internal damping, vibration absorption

The theoretical prediction that significant regions of attenuation exist in the transmissibility curves of cantilever beams driven by dual forces of like magnitude and phase is substantiated. Reciprocal experiments made on small aluminum beams and a laminated steel/viscoelastic beam are described. The attenuation provided by the laminated beam is remarkably extensive and exceeds 15 dB at frequencies above 100 Hz, and 20 dB at frequencies above 1.2 kHz. Agreement between theoretical prediction and reciprocal experiment is noted in two other cases: (1) where the large region of attenuation predicted is doubled in width and deepened by a factor of more than 10 when the beam is loaded by a suitably positioned lumped mass of similar magnitude to the beam mass, and (2) where a uniform cantilever beam is driven by forces transmitted by two resilient mountings that support a vibrating mass. The natural frequency of this simple mounting system fell well below the fundamental resonant frequency of the cantilever beam, thus, the mounting system and the beam vibrated more or less independently. The attenuation afforded by the simple mounting, essentially 12 dB/octave, superimposed on the region of attenuation noted previously in the beam transmissibility and provided an extremely large and continuous region of attenuation in the transmissibility across the combined simple mounting/beam system at all but low frequencies.

72—634

VIBRATION OF PLANE CURVED BEAMS
Strom, B.T.
108 pp (1971)

Key Words: beams, mode shapes, natural frequencies

An analysis leading to equations governing in-plane motion of plane curved bars is presented. The equations are used to predict, via the state vector/transfer matrix approach, natural frequencies and mode shapes for bars supported in a variety of different ways. The general transfer matrix is formulated using the exact solution to the differential equations of motion for a beam of constant curvature. These equations include the effects of rotatory inertia, shear deformation, and extensional deformation. The general transfer matrix can be used to obtain the natural frequencies and mode shapes for a constant curvature beam, or a number of transfer matrixes can be used to obtain the natural frequencies and mode shapes for a beam in which the curvature or the beam properties vary. The natural frequencies are obtained by finding the zeroes of the appropriate three-by-three subdeterminant of the overall transfer matrix. Data is presented for a straight beam, a circular beam with three different opening angles, $\pi/2$, $3\pi/4$, and π, a hook-shaped beam and a parabolic-shaped beam, all for various boundary conditions. The results are compared to experimental data, data obtained using a straight element approximation, and published results where available. An example of the use of the state vector/transfer matrix approach applied to the extensional vibration of a thin rod is included.
UM 72-3004

72—635

DYNAMIC CANTING STABILITY OF AN ELASTIC BEAM OF NARROW CROSS SECTION UNDER A TRANSVERSE FOLLOWER FORCE STRESS
Wohlhart, K. (Deutsche Forschungs-Und Versuchsanstalt Fuer Luft-Und Raumfahrt E V Proz-Wahn, West Germany)
Avail: Pub. in Zeitschrift fuer Flugwissenschaften 19(7), 291-298 (1971); 8 pp (Aug. 17, 1970)

Key Words: beams, buckling, dynamic stability

Lateral buckling stability of the equilibrium position of an elastic beam with narrow cross section, acted upon by a transversal follower force, is investigated. The beam clamped on one end has constant mass distribution over the length, and a concentrated mass fixed in a cross section. In the same cross section a follower force is acting. The direction of the force depends on the angle of twist of the cross section. (In German)
AD-733600

BEARINGS

72—636

APPLICATION OF AIR BEARINGS TO HIGH SPEED TURBOMACHINERY
Barnett, M.A. and Silver, A. (AiResearch Manuf. Co.)
SAE Paper No. 700720 (Sept. 14-17, 1970) 3 refs

Key Words: gas bearings, turbomachinery

The advantages and problems in the application of air bearings to closed- and open-cycle machinery are described. The design and performance characteristics of several prototype air bearing machines are discussed. The results of extensive ground tests and thousands of hours of field experience prove that practical air bearing turbomachines for open-cycle applications are a reality

72—637

CONSIDERATIONS ON THE STIFFNESS OF EXTERNALLY PRESSURIZED JOURNAL BEARINGS
Michelini, R.C. and Ghigliazza, R.S. (Universita di Genova, Istituto de Meccanica Applicata alle Macchine, Genova, Italy)
J. Lubrication Tech., Trans. ASME 93(4), 504-511 (Oct. 1971) 20 refs

Key Words: bearing response, journal bearings

A direct method of computation that fully allows for hydrodynamic effects in the correct design of externally pressurized journal bearings fed with incompressible lubricant is presented. The performance of bearings with independent and cross-related recesses is analyzed thoroughly, and the influence of hydrodynamic effects and the feeding system on bearing stiffness is determined.

BLADES

(Also see No. 730)

72—638

TORSIONAL VIBRATION OF A ROTATING TAPERED-TWISTED TURBOMACHINE BLADE
Krupka, R.M. and Baumanis, A.M. (Continental Aviation and Engr. Corp.)
SAE Paper No. 700180 (Jan. 12-16, 1970) 12 refs

Key Words: rotating structures, torsional response, turbine blades

This paper treats the torsional vibration of a rotating tapered and twisted turbomachine blade. Carnegie's formulation of the Lagrange equations of motion is used and the set of field equations solved using Myklestad's adaptation of the Holzer method. Digital computer results are presented for a particular turbine blade, demonstrating the convergence of the method and the satisfaction of the boundary conditions of the problem. The equations and methodology required to construct a digital computer program, in order to obtain a numerical solution to the problem, are derived.

72—639

EXPERIMENTAL STUDY OF ROTOR UNSTEADY AIRLOADS DUE TO BLADE-VORTEX INTERACTION
Padakannaya, R. (Pa. State Univ., University Park, Pa.)
NASA-CR-1909, 37 pp (Nov. 1971)

Key Words: aerodynamic excitation, rotor blades

Measurements of unsteady, rotor-blade airloads and their time derivatives are presented for a rotor blade intersecting a completely rolled-up vortex. These results, taken at the blade spanwise station of 0.9R, 0.85R, and 0.75R, complement measurements previously reported for the 0.95R station in CR-1573. Incremental values in the section lift coefficient as high as 1.17 are obtained at the 0.75R station. Generally, these values decrease with increasing radius.
N71-37598

COLUMNS

72—640

DYNAMIC INSTABILITY OF A CANTILEVER COLUMN SUBJECTED TO A FOLLOWER FORCE INCLUDING THERMOMECHANICAL COUPLING EFFECT
Shieh, R.C. (NASA-Langley Res. Ctr., Hampton, Va.)
J. Appl. Mech., Trans. ASME 38(4), 839-846 (Dec. 1971) 22 refs

Key Words: cantilever beams, dynamic stability, follower force

The dynamic instability of equilibrium of an elastic cantilever column subjected to a follower type force at its free end is studied. The surfaces of the column are either kept at constant temperature (isothermal) or are thermally insulated (adiabatic). The boundary-value problem is solved in general and in particular for

the depth-length ratio. Numerical results for the critical loads are given for various values of the thermal parameters and it is shown that for a tangential follower force, the critical dynamic instability load may be reduced through the coupling effect to approximately one-half that of the corresponding uncoupled isothermal problem which was solved by Beck. Analytical results are obtained for the damping coefficients for both adiabatic and isothermal boundary conditions. It appears that material damping, at least for this material, is almost entirely attributable to thermomechanical coupling.

CONTROLS

72—641

PREDICTING PENETRATION RATES OF PLOWS WITH COMBINED VERTICAL AND FORE-AFT VIBRATION AND FLEXIBLE BLADES
Senator, M. and Warren, R.E. (Bell Telephone Labs., Inc.)
SAE Paper No. 700040 (Jan. 12-16, 1970)
2 refs

Key Words: agricultural machinery, vibrators (machines)

Three soil models are developed which retain much of the simplicity of a previously proposed modified Coulomb soil model, yet which allow penetration rates to be predicted for vibrating plows that combine suitable phased vertical blade motion with fore-aft blade vibration. In addition a method is developed for accounting for blade flexibility in a manner which is compatible with the simplicity of models. The main new soil model is based on the assumption of a constant amount of energy being necessary to penetrate a unit volume of soil.

MECHANICAL

72—642

ENGINEERING ANOMALIES AND MISCONCEPTIONS
Harris, W.R. (Dept. Chem. Engr., Bucknell Tech. Col.)
Engr. Matl. Design 14(11), 1119-1120 (Dec. 1971)

Key Words: bolts, shock response

When a bolt is put into tension, it normally fails by the stress exceeding the ultimate tensile strength. Under these circumstances, the load which the bolt will carry will be proportional to the cross-sectional area. However, if a sudden load is applied, the shock energy must be absorbed by the bolt if failure is not to occur. The ability of a bolt to resist a shock loading is discussed.

MEMBRANES

72—643

VIBRATIONS OF A LOADED KETTLEDRUM
De, S. (Dept. Phys., Visva-Bharati, Old Engr. Office, Santiniketan, Birbhum, West Bengal, India)
J. Sound and Vib. 20(1), 79-92 (Jan. 8, 1972) 10 refs

Key Words: frequency response, musical instruments

The effect on the frequency of a vibrating kettledrum of the application of a mass load at a point is discussed.

PANELS

(Also see No. 607)

72—644

MODAL ANALYSIS OF A NINE-BAY SKIN-STRINGER PANEL
Grandle, R.E. and Rucker, C.E. (NASA-Langley Res. Ctr.)
Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Research Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 343-361

Key Words: computer programs, finite element technique, NASTRAN, normal modes, panels

Results obtained using a NASTRAN normal mode analysis of a nine-bay skin-stringer panel (27 by 37 in.) are presented. The aluminum panel is made up of a plate, Z section stringers, and channel section frames and is assumed to have fully fixed edges. Stress and mode shape data for the lower order modes obtained from a NASTRAN analysis of a 266 grid-point division of the panel are presented and compared with experimental data.

72—645

SOME ASPECTS OF FLUTTER OF CYLINDRICAL PANELS
Salvioni, L. (Istituto di Ingegneria Aerospaziale, Politecnico di Milano, Italy)
Meccanica 6(3), 139-146 (Sept. 1971) 8 refs

Key Words: curved panels, flutter

Some aspects of the flutter of weakly curved panels are investigated. A new system of visual presentation of the results makes the analog computer study easier. An improvement in the calculating circuit permits continuous variation both of the flutter parameter and the compression load during calculation.

PIPES

72—646

ACOUSTIC ATTENUATION IN RIGID AND ROUGH TUBES WITH TURBULENT AIR FLOW
Ahrens, C and Ronneberger, D. (Physikalisches Institut der Universität Göttingen, Germany)
Acustica 25(3), 150-157 (Sept. 1971) 12 refs

Key Words: measurement techniques, noise reduction, surface roughness, test data, tubes

The acoustic attenuation of the principal mode in rigid tubes, with smooth and rough walls, measured when air flowed turbulently through the tube, is reported. The data are compared with the results of a calculation taking into account the flow profile and the gradient of the static pressure, but neglecting the effects of turbulence. Above a definite flow velocity the difference between measured and calculated data increases with increasing flow velocity. This definite flow velocity depends on the wall roughness and the frequency of the sound wave, suggesting that the difference between measured and calculated attenuation is connected with the turbulence structure in the vicinity of the wall. (In German)

72—647

QUIETING HYDRAULIC SYSTEMS AND COMPONENTS
Becker, R.J. (Vickers Inc.)
SAE Paper No. 700711 (Sept. 14-17, 1970) 5 refs

Key Words: hydraulic systems, noise reduction

The noise generated in a hydraulic system is discussed. The noise occurs in three forms: audible sound, structural vibration, and fluid pressure pulsations. The selection of quiet pumps, although an important step, does not necessarily quiet the operating system. The elimination of entrained air in the system fluid may not remove the problem. Frequently, a tradeoff of operating parameters in a pump or motor is the best means of noise control. Installation practices are important and may require isolation of the pump or motor assembly from the rest of the machine structure.

72—648

VIBRATION AND STABILITY OF A UNIFORMLY CURVED TUBE CONVEYING FLUID
Chen, S.S. (Engr. Tech. Div., Argonne Natl. Lab., Argonne, Ill.)
J. Acoust. Soc. Am. 51(1), 223-232 (Jan. 1972) 28 refs

Key Words: fluid-filled containers, natural frequencies, stability, tubes

A theoretical study of the vibration and stability of a uniformly curved tube containing flowing fluid is presented. The tube is assumed to be inextensible. A solution for the natural frequency is obtained. Numerical results are presented. A discussion of the effects of flow velocity, fluid pressure, and the coriolis force on the natural frequency is included. When the flow velocity and fluid pressure exceed a certain value, the tube becomes subject to buckling-type instability. Critical loads are presented for fixed-fixed, hinged-hinged, and fixed-hinged end conditions in terms of the flow velocity and fluid pressure.

72—649

THE TRANSIENT CHARACTER OF THE NEARFIELD ACOUSTIC RADIATION FROM A CYLINDRICAL DIAPHRAGM EXCITED BY WATER HAMMER TRANSIENTS
Davis, B.W. and Veynand, E.E. (N. Ariz. Univ., Flagstaff, Ariz.)
J. Engr. Indus., Trans. ASME 93(4), 1216-1224 (Nov. 1971) 9 refs

Key Words: piping, transient response, water hammer

The transient character of the nearfield acoustic radiation from a water hammer excited, cylindrical diaphragm is investigated. The investigation focuses on relating the radiated waveforms to pressure transients within the pipe. The basic experimental system consists of a length of rigid pipe extending from a flow source

into a large sonar tank. The pipe is interrupted by a cylindrical section of elastomeric tubing which serves as a diaphragm and thus, as an acoustic coupler between the water inside the pipe and the water surrounding the pipe. A quick-closing valve downstream of the diaphragm produces water hammer transients which are coupled to the surrounding water through the diaphragm and monitored in the nearfield by hydrophones. The physical system geometry is varied to include data for a range of pipe sizes. These are from 0.5 in. to 4.0 in. ID and from 10 ft to 34 ft in length. The experiments revealed that two distinct major waves are identified in each radiated wave pattern: one originating from the primary water hammer compressive wave downstream of the diaphragm; the other arising from a precursor wave which originated upstream of the diaphragm.

72—650

APPLICATIONS OF NASTRAN TO COUPLED STRUCTURAL AND HYDRODYNAMIC RESPONSES IN AIRCRAFT HYDRAULIC SYSTEMS
Howlett, J.T. (NASA-Langley Res. Ctr., Hampton, Va.)
Presented at Colloquium NASTRAN· User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 19 pp, 5 refs

Key Words: coupled response, finite element technique, fluid filled containers, NASTRAN, piping

This paper demonstrates that the NASTRAN computer program can be used to analyze the coupled fluid and structural responses of multi-branch pipes as occur in aircraft hydraulic systems. The techniques used to model hydraulic lines with NASTRAN are explained. Example problems are presented which demonstrate the validity of the analytical model for a simple standpipe system and which demonstrate that the technique is promising as a basis for detailed dynamic analysis of hydraulic systems of actual aircraft.

72—651

DYNAMIC EXPANSION OF AN OPEN-ENDED TUBE
Lal, G.K. and Hillier, M.J. (Dept. Mech. Engr., Carnegie-Mellon Univ., Pittsburgh, Pa.)
J. Basic Engr., Trans. ASME 93(4), 681-684 (Dec. 1971) 4 refs

Key Words: modeling, tubes

The deformation mode of a thin tube subjected to an arbitrary time varying pressure pulse is investigated. Two phases occur: (1) during positive radial acceleration a zone of zero axial strain sweeps outward from the central plane toward the ends; and (2) on deceleration to rest, the plane strain zone vanishes, the axial stress changes sign, and the stress ratio is then unconstrained. The final tube profile is essentially uniform except near the ends. The final change in length is small.

72—652

CAVITATION IN HIGH-HEAD CONDUIT CONTROL DISSIPATORS
Ripken, J.F. and Hayakawa, N.
J. Hydraulics Div., Proc. ASCE 98(HY1), 239-256 (Jan. 1972) 14 refs

Key Words: cavitation, hydraulic structures

The wasting of water from high-head hydraulic structures through a closed conduit requires an economical control and energy dissipator device which will safely contain the potentially destructive cavitation prone flow. Hydraulic design criteria for a valve-orifice-chamber type of control dissipator are reviewed with regard to the influence that cavitation has on flow capacity, vibration, noise, and erosion. Orifices modified with peripheral devices to break up the continuity of the troublesome vortex rings show substantial performance benefits when tested.

72—653

FORCE AND STABILITY MEASUREMENTS ON MODELS OF SUBMERGED PIPELINES
Wilson, J.F. and Caldwell, H.M. (Dept. Civil Engr., Duke Univ., Durham, N.C.)
J. Engr. Indus., Trans. ASME 93(4), 1290-1298 (Nov. 1971) 26 refs

Key Words: natural frequencies, piping, submerged structures

The effects of currents on pipes anchored just above the ocean floor is studied. Lift, drag, and stability of two parallel pipes, parallel to a flat plane (the sea floor) are measured. Simulated ocean currents up to two knots at several subcritical, free stream Reynolds numbers are used. A wind tunnel is utilized to find the lift and drag coefficients on two parallel, rigid, cylindrical models. The effects of horizontal spacing, vertical spacing from the ground plane, and orientation angle of the horizontal free stream velocity are observed and these results are compared to data available for the single and double cylinder cases where the ground plane is absent. A water tow tank is used to observe conditions for vortex-shedding induced vibrations for fixed end, flexible, parallel cylinders.

PLATES AND SHELLS

(Also see Nos. 544, 556, 564, 565, 614, 656)

72-654

TRANSIENT RESPONSE OF SUBMERGED SPHEROIDAL SHELLS

Bedrosian, B. and DiMaggio, F.L. (Dept. Civil Engr. and Engr. Mech., Columbia Univ., New York, N.Y.)

Intl. J. Solids Struc. 8(1), 111-129 (Jan. 1972) 16 refs

Key Words: shells, submerged structures, transient response

The transient response of an elastic prolate spheroidal shell to a uniform pressure suddenly applied to its surface, and the pressure field in the surrounding acoustic fluid are obtained. By appropriate transformations of response functions and a geometric variable the problem is reduced to the simultaneous numerical integration, in a finite domain, of partial differential equations on functions which are regular in the space variables. An approximate relation is established to represent the fluid field, which, together with the plane wave approximation, is then used to obtain approximate solutions for the shell response. Extensive numerical results are presented for steel shells in sea water.

72-655

MODES OF VIBRATION IN A CIRCULAR PLATE WITH THREE SIMPLE SUPPORT POINTS

Chi, C. (The Perkin-Elmer Corp., Wilton, Conn.)

AIAA J. 10(2), 142-147 (Feb. 1972) 11 refs

Key Words: circular plates, mode shapes

Analytical solutions for the vibrational modes of thin circular flat plates that are simply supported at three points on the circumference are presented. The mode shapes and corresponding eigenvalues are obtained. Results show that the modes can be grouped into four different types depending on the manner by which they receive the pressure at the supported points. The problem is of the mixed boundary value type in that some portion of the boundary is free while the other portion is simply supported.

72-656

VIBRATION OF SIMPLY-SUPPORTED TRAPEZOIDAL PLATES -- PART I: SYMMETRIC TRAPEZOIDS

Chopra, I. and Durvasula, S. (Natl. Aeronaut. Lab., Bangalore, India)

J. Sound and Vib. 19(4), 379-392 (Dec. 22, 1971) 12 refs

Key Words: mode shapes, natural frequencies, trapezoidal plates

A detailed investigation of the natural frequencies and mode shapes of simply-supported symmetric trapezoidal plates is undertaken. For numerical calculations, the relationship that exists between the eigenvalue problem of a polygonal simply supported plate and the eigenvalue problem of polygonal membrane of the same shape is utilized with advantage. The deflection surface is expressed in terms of a Fourier sine series in transformed coordinates and the Galerkin method is used. Results are presented in the form of tables and graphs. Several features like the crossing of frequency curves and the metamorphosis of some of the nodal patterns are observed. By a suitable interpretation of the modes of those symmetric trapezoidal plates which have the median as the nodal line, the results for some of the modes of unsymmetrical trapezoidal plates are also deduced.

72-657

VIBRATION OF SIMPLY-SUPPORTED TRAPEZOIDAL PLATES -- PART II: UNSYMMETRIC TRAPEZOIDS

Chopra, I. and Durvasula, S. (Natl. Aeronaut. Lab., Bangalore, India)

J. Sound and Vib. 20(2), 125-134 (Jan. 22, 1972) 6 refs

Key Words: mode shapes, natural frequencies, trapezoidal plates

Vibration characteristics of simply-supported unsymmetric trapezoidal plates are investigated. For numerical calculations, the relationship between the eigenvalue problems of a polygonal simply supported plate and a polygonal membrane is again effectively utilized. The Galerkin method is applied, with the deflection surface expressed in terms of a Fourier sine series in transformed coordinates. Numerical values for the first seven to eight frequencies for different geometries of the unsymmetric trapezoid are presented. Also the nodal patterns for a few representative configurations are presented.

72-658

FORCE AND MOMENT ADMITTANCE OF PLATES UNDER ARBITRARY FLUID LOADING

Crighton, D.G. (Dept. Math., Imperial Col. Sci. Tech., London S.W.7, England)
J. Sound and Vib. 20(2), 209-218 (Jan. 22, 1972) 6 refs

Key Words: acoustic excitation, plates, submerged structures

Exact closed form expressions are given for the line force and moment admittances of an infinite thin elastic plate immersed in compressible fluid. Very simple approximations to the admittances are found in the heavy fluid loading limit. The approximations are shown to completely cover the low frequency range which has previously not been dealt with, even by the numerical computations of Nayak. The plate response throughout the nearfield of the line of excitation is also obtained in simple form.

72-659

TRANSVERSE VIBRATION OF A CLASS OF ORTHOTROPIC PLATES

De Capua, N.J.
111 pp (1971)

Key Words: flexural vibration, orthotropic plates, plates

The eigenvalues, eigenvectors, and nodal patterns of a class of orthotropic plates are determined. The plate geometry is governed by the equation,

$$\left(\frac{x}{a}\right)^{\alpha} + \left(\frac{y}{b}\right)^{\beta} = 1$$

where a, b, α, and β permit the plate geometry to vary over a range which includes the rhombus, circle, ellipse, square, and rectangle. Variable thickness, in-plane forces, and mixed or discontinuous boundary conditions are also considered. The Rayleigh-Ritz energy technique is employed using xy-polynomials as the approximated deflection. Eigenvalues and eigenvectors are computed by the method of reductions, and the evaluation of double integrals is achieved by the numerical procedure of Gauss-Legendre quadratures. The calculated frequencies and nodal patterns are in good agreement with existing data.
UM 71-30,012

72-660

FINDING FLAT-PLATE NATURAL FREQUENCY

Dunn, W.P. (TRW Syst., Redondo Beach, Calif.)
Mach. Design 43(23), 152-153 (Sept. 16, 1971) 4 refs

Key Words: natural frequencies, plates

Determining the natural frequency of uniformly loaded, flat plates can be greatly simplified by using the peak static deflection of the plate. Peak static deflection is an easily determined value in most cases, and it may be used to determine the natural frequency, which is required to analyze dynamic plate deflections. A simple equation for natural frequency using frequency constants and peak static deflection is derived for uniformly loaded flat plates of constant thickness. Frequency constants are tabulated for various plates of commonly encountered shapes and boundary conditions.

72-661

CIRCUMFERENTIAL WAVES IN A THIN-WALLED AIR-FILLED CYLINDER IN A WATER MEDIUM

Horton, C.W., Sr. and Mechler, M.V. (Appl. Res. Labs., Univ. Tex., Austin, Tex.)
J. Acoust. Soc. Am. 51(1), 295-303 (Jan. 1972) 12 refs

Key Words: cylinders, submerged structures, wave diffraction

Values of group and phase velocity are measured for circumferential waves around a thin-walled air-filled aluminum cylinder when the cylinder is immersed in water. Experimental values of attenuation are measured for pulses. These experiments are carried out for frequencies from 50 to 200 kHz. A theoretical analysis based on the equivalent mechanical impedance of a thin-walled elastic shell is developed. Numerical values are compared with the experimental data.

72-662

THE RESPONSE OF SHELLS TO DISTRIBUTED RANDOM LOADS USING NASTRAN

Jones, G.K. (Goddard Space Flight Ctr.)
Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 12 pp, 1 ref

Key Words: cylindrical shell, finite element technique, NASTRAN, random response

The performance of the NASTRAN modal random response analysis, rigid format 11, is investigated using a hypothetical stiffened cylindrical shell excited by a simulated turbulent boundary layer pressure field. The cylindrical shell (2.54 m diam, 3.353 m in length) is simply supported at both ends. Two models are used, one with 360 degrees of freedom, the other with 720. The real part of the forcing function (co-spectral density) is represented by an exponentially decaying cosine function and the imaginary part of the forcing function (quad-spectral density) is represented by an exponentially decaying sine function. Only the random response (displacement spectral density) obtained for the 360 degree-of-freedom model is presented.

72—663

AN EXPERIMENTAL STUDY INTO THE DYNAMIC INELASTIC BEHAVIOR OF SPHERICAL SHELLS AND SHELL INTERSECTIONS

Jones, N.; Giannotti, J.G.; and Grassit, K.E. (Dept. Ocean Engr., Mass. Inst. Tech., Cambridge, Mass.)

35 pp (Aug. 1971)

Key Words: impact tests, spherical shells

An experimental investigation into the dynamic inelastic behavior of fully clamped hemispherical shells with and without radially intersecting cylindrical nozzles is reported. The models are subjected to impulsive velocities which are distributed uniformly over the inside surfaces of the shells. Tests are conducted on specimens made from hot rolled mild steel, which is highly strain rate sensitive, and repeated on Aluminum 6061 T6, which is almost strain rate insensitive.
AD-733079

72—664

AIR BLAST RESPONSE OF CYLINDRICAL MEMBERS

Kim, Y.S.

210 pp (1971)

Key Words: beams, cylindrical shells, dynamic response

The elastic responses of some circular members when subjected to a transverse plane air blast wave are investigated. The items studied are a circular cantilever beam and an infinitely long circular cylindrical shell. An analytical study made both in the time domain and in the frequency domain is described. From the elastic response of the cantilever beam, the drag force is obtained using a method which converts the response in the time domain into the frequency domain and then back from the frequency domain to the time domain. In this procedure, the Fast Fourier Transform is employed. The conversion method makes use of "the cutting impulse technique" reported. Two circular aluminum cantilever beams of lengths 5 and 2-1/2 ft and of diameters 3 and 2 in., respectively, are tested at the 11 psi nominal overpressure location during a 500 ton TNT field explosion at Defence Research Establishment Suffield. From the measured response, the drag force is obtained.
UM 72-4157

72—665

ON EQUIVOLUMINAL VIBRATION MODES OF A MULTIPOLAR ELASTIC PLATE

Keeble, R.H. and Weitsman, Y. (Dept. Mech. Engr., Univ. Nairobi, P.O. Box 30197, Nairobi, Kenya)

J. Sound and Vib. 20(2), 169-175 (Jan. 22, 1972) 6 refs

Key Words: normal modes, plates

A special vibration mode of a plate composed of an elastic material with an oriented microstructure is investigated according to a multipolar elastic theory. An equivoluminal mode of a finite plate analogous to the Lamé mode is sought. However, in the context of multipolar theory, this mode does not exist because the angle at which transverse waves reflect as themselves is not 45 deg as it is in classical theory. Equivoluminal vibration modes of an infinite plate with traction-free plate faces are developed.

72—666

DYNAMIC RESPONSE OF CYLINDRICAL SHELLS WITH INITIAL STRESS AND SUBJECTED TO GENERAL THREE-DIMENSIONAL SURFACE LOADS

Liao, E.N.K. and Kessel, P.G. (Nuclear Energy Syst., Westinghouse Elec. Corp. Pittsburgh, Pa.)

J. Appl. Mech., Trans. ASME 38(4), 978-986 (Dec. 1971) 10 refs

Key Words: cylindrical shells, dynamic response

General solutions are presented for both Flügge's and Donnell's equations governing the displacements of the midsurface of a thin circular cylindrical shell, simply supported at both ends, of finite length, under initial two-way stress and subjected to general time-dependent surface loads. Analytical solutions to the specific problems of a stationary radial point force and a stationary point couple are presented. A numerical comparison of Donnell's and Flügge's theories

is made for these specific problems for a wide variety of shell parameters. For the case of a dynamic point force or point couple, it is found that Donnell's theory is satisfactory for thin and very short shells ($h/a \leq 0.01$ and $1/a \leq 2$).

72—667

LONGITUDINAL IMPACT OF CYLINDRICAL SHELLS
Mortimer, R.W.; Rose, J.L.; and Chou, P.C. (Drexel Univ., Philadelphia, Pa.)
Experimental Mech. 12(1), 25-31 (Jan. 1972) 9 refs

Key Words: cylindrical shells experimental results, transient response

The transient response due to longitudinal impact of three aluminum cylindrical shells of different thickness-to-radius ratios is studied both analytically and experimentally. The analyses are obtained from method of characteristics' solutions of two sets of equations: one which includes the transverse shear, radial inertia and rotary inertial effects, and the other set is from a modified membrane theory. Experimentally, longitudinal and circumferential strains are monitored along the length of each of the shells; the velocity of the impacter ring is also measured. The experimental results of this study indicate that the wave front, after traveling three diameters from the impacted end, propagates at essentially the plate velocity, in agreement with the theory. In addition, the longitudinal and circumferential strains calculated from the two theories are in good agreement with the experimental results.

72—668

DYNAMIC BUCKLING OF THIN ELASTIC SHELLS
Nash, W.A. (Engr. Indus. Experimental Station, Florida Univ., Gainesville, Fla.)
105 pp (June 1971)

Key Words: dynamic buckling, thin shells

Five studies in the statics and dynamics of thin elastic shells of cylindrical, spherical, and conical shape are summarized. Various types of time-dependent loads are considered and the responses of the shells are investigated by a variety of techniques. Agreement of theory with available experimental evidence is discussed where possible.
AD-726397

72—669

THEORY OF VIBRATION OF CRYSTAL PLATES AT HIGH FREQUENCIES
Nikodem, Z.
159 pp (1971)

Key Words: plates, quartz, vibration response

A new series expansion of displacement is employed in a two-dimensional approximation of exact three-dimensional equations. The dependence of the displacement in the normal direction of the plate is expressed by an infinite series of the thickness modes. The nth order strain-displacement relations, stress-strain relations and stress equations of motion are derived for the approximate two-dimensional theory. Approximate theories of various orders from 0 to 10 are investigated. The dispersion curves for real, imaginary and complex wavenumbers in the case of the propagation of straight-crested waves in an infinite crystal plate with monoclinic symmetry, such as AT-cut quartz plate, are explored in detail and compared with the exact dispersion curves obtained from the three-dimensional theory of elasticity. The close agreement between these two sets of curves indicates that the nth order theory approximates the exact theory accurately up to the dimensionless frequency $\Omega = n + \frac{1}{2}$, and therefore the solution of the approximate equations, for bounded plates, will give reliable results.
UM 72-2736

72—670

ON THE RESPONSE OF ELASTIC PLATES BACKED BY ENCLOSED CAVITIES TO TURBULENT FLOW EXCITATIONS
Obermeier, F. (Acoust. Vib. Lab., Mass. Inst. Tech., Cambridge, Mass.)
47 pp (Apr. 1971)

Key Words: cavity resonance, plates

Some special points of the basic mechanisms of sound generation and structure borne sound caused by the interaction between turbulent boundary layer flows and thin, elastic plates backed by cavities are examined. The specific differences of the excitation by turbulent boundary layer flows compared with that by sound fields are discussed and the responses of the vibrating system in the case of the excitation of natural frequencies either of the plate or of the cavity are determined.
AD-732004

72—671

FLUTTER OF THIN CYLINDRICAL SHELLS CONVEYING FLUID
Paidoussis, M.P. and Denise, J.P. (Dept. Mech. Engr., McGill Univ., Montreal 101, Canada)
J. Sound and Vib. 20(1), 9-26 (Jan. 8, 1971) 16 refs

Key Words: cylindrical shells, fluid-filled containers, flutter

When the flow velocity in a finite, thin, circular cylindrical shell, either clamped at both ends or cantilevered, exceeds a certain critical value, the system is observed to lose stability by flutter in its second circumferential mode. This paper describes the phenomenon, and presents a theory for its analysis which is based on Flügge's equations for the description of shell motion and a classical potential-flow theory for the coupled hydrodynamic forces. Complex frequency calculations reveal the existence of flutter in the case of cantilevered shells; for clamped-clamped shells the theory predicts buckling instability followed by coupled-mode flutter. Theory and experiment are in adequately close agreement.

72—672

VIBRATION AND STABILITY OF RECTANGULAR PLATES WITH MIXED BOUNDARY CONDITIONS
Stahl, B.
123 pp (1971)

Key Words: cracked structures, rectangular plates, vibration response

The vibration and buckling of rectangular plates having mixed boundary conditions are investigated. Plates which are partially cracked, partially clamped, and partially supported are treated. The problems are formulated as dual series equations and reduced to homogeneous Fredholm integral equations of the second kind. Numerical results are obtained for a variety of cases and are compared to results obtained by other available techniques. Specific problems analyzed are simply supported plates which are cracked along one line of symmetry and plates which are partially clamped and partially simply supported. Natural frequencies and buckling loads are calculated as functions of crack and clamp lengths. Contours of constant deflections are drawn for some of the vibration and buckling modes. For the case of the cracked plate, moment distributions are calculated along the uncracked segment. Each of the solutions presented exhibits a square root moment singularity at the point of discontinuity of the boundary conditions. A plate with an internal support and a plate which is simply supported adjacent to the corners are also analyzed.
UM 71-30,956

72—673

VIBRATION AND STABILITY OF CRACKED RECTANGULAR PLATES
Stahl, B. and Keer, L.M. (AMOCO Production Co., Tulsa, Okla.)
Intl. J. Solids Struc. 8(1), 69-91 (Jan. 1972) 17 refs

Key Words: cracked structures, rectangular plates, vibration response

Eigenvalue problems of cracked rectangular plates are studied. Vibration and buckling problems are solved for a plate with a crack emanating from one edge and for a plate with a centrally located internal crack. The problems are formulated as dual series equations and reduced to homogeneous Fredholm integral equations of the second kind. The singularity of the solution in each case is isolated and treated analytically. Numerical results for the natural frequencies and moment distributions are compared with the work of other investigators. Vibration and buckling mode shapes are also illustrated for a cracked plate.

72—674

DYNAMIC RESPONSE OF CIRCULAR PLATES SUBJECTED TO MOVING MASSIVE LOADS
Stahl, K. J.
183 pp (1971)

Key Words: circular plates, dynamic response, moving loads

Techniques are presented for studying the dynamic response of circular disks excited by moving loads. The loading system, consisting of a mass, spring, and dashpot, travels in a circular path concentric with the disk at constant angular velocity. For cases involving elastically-supported rigid disks, the equations of motion for the disk and moving load may be written as a set of coupled Hill-Mathieu equations, typical of moving mass problems. When the eigenvalues are pure imaginary numbers, they correspond to the frequency components in the motion of the moving mass, and describe the disk motion as well. In certain regions the eigenvalues have positive real parts, corresponding to motions which are unbounded in time. There are three distinct regions of instability which appear in the rigid disk problem. The dynamic response of circular elastic disks with similar loading is investigated using the conventional eigenfunction

expansion technique. The system of coupled Hill-Mathieu equations obtained by applying this method reduces to an ordinary eigenvalue problem when certain transformations are made, thus, many modes may be included in the solution. Solutions to the eigenvalue problem reveal regions of instability directly analogous to those observed in the rigid disk examples.
UM 72-491

72—675

LIQUID OSCILLATION FREQUENCIES ON TILTED CYLINDERS FOR FIVE CROSS SECTION SHAPES
Thornton, S. and Bugg, F. (NASA-Marshall Space Flight Ctr., Huntsville, Ala.)
NASA-TM-X-64618, 28 pp (Oct. 1971)

Key Words: cylindrical shells, fluid-filled containers, sloshing

The frequency of liquid oscillations measured in cylindrical tanks with cross section shapes formed by a circular arc and a straight line is reported. The shapes are related to some feasible and proposed space shuttle tank cross sections and range from circular to approximately semicircular. The frequencies are measured with the tank axes tilted 0 to 60 deg from the local vertical. Oscillations are excited both by forces in the plane of the tilt angle and forces perpendicular to the plane of the tilt angle. The data are compared with theoretical results for frequency in tilted circular cylindrical tanks and theoretical results for one upright cylindrical tank with noncircular cross section.
N71-38707

SPRINGS

72—676

STUDY OF THE DYNAMIC RESPONSE OF BELLEVILLE WASHERS AND RING SPRINGS
Guzdar, A.R.; Rhee, S.S.; and Monaghan, D.A. (Fosier-Miller Assoc., Inc., Waltham, Mass.)
138 pp (Oct. 1971)

Key Words: dynamic response, springs

Analyses and experiments conducted on the propagation of surge waves in Belleville washers and ring springs under impact with a moving mass and sudden release from a precompressed state are discussed. Springs are analyzed with the use of a multiple-element model with mass and damping in addition to a simplified single element model in which the spring is considered as an equivalent bar. The analysis of the multiple-element model deals with nonlinearities in the load-deflection curve, and Coulomb friction between the spring elements. Time-displacement records of surge-wave propagation are obtained on three types of Belleville washer assemblies and on two designs of ring springs under conditions of dynamic impact and sudden release.
AD-733349

SYSTEMS

ACOUSTIC ISOLATION
(Also see No. 733)

72—677

THE PERFORMANCE OF SOUND ABSORBERS IN A RADIAL DIFFUSER CONFIGURATION
Scott, H.L. (Simon-Carves Ltd., Cheadle Heath, Stockport SK3 0RY, England)
J. Sound and Vib. 19(4), 445-451 (Dec. 22, 1971) 5 refs

Key Words: acoustic linings, noise reduction

A classical wave theory approach is used to determine the radial attenuation in a simulated centrifugal fan or pump diffuser lined with sound absorbing material. For all circumferential modes the attenuation at large radii is virtually the same as that of the lowest mode in a rectangular duct lined on two opposite sides. However, at small radii, the attenuation rate increases markedly above the rectangular duct lowest mode value as the number of nodal diameters is increased.

AIRCRAFT
(Also see No. 572)

72—678

STATIC AND DYNAMIC ANALYSIS, F-14A BORON HORIZONTAL STABILIZER
Huang, S.L. and Rubin, H. (Naval Air Dev. Ctr.)
Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 13 pp

Key Words: aircraft, computer program, finite element technique, modal analysis, NASTRAN

Static stress and dynamic modal analyses of the horizontal stabilizer of the F-14A aircraft are reported. The structural model contains 1518 elements including bars, rods, shear panels and orthotropic and isotropic membrane elements with 1357 degrees of freedom. Static deflection and stresses, including thermal stresses, under maximum load at room and at elevated temperatures are calculated and results are in good agreement with experimental data. Through application of "Guyan Reduction" the number of degrees of freedom used in the dynamic analysis is reduced to 137. The frequencies and mode shapes for the first two modes are obtained.

72—679

HOVERCRAFT NOISE AND VIBRATION
Lovesey, E.J. (Engr. Phys. Dept., Royal Aircraft Estab., Farnborough, England)
J. Sound and Vib. 20(2), 241-245
(Jan. 22, 1972) 4 refs

Key Words: ground effect machines, noise reduction, vibration control

Hovercraft are a relatively new and unique form of transport, capable of traversing terrains which hitherto have been almost impassable at speed by surface transport. This high-speed capability was gained partially at the cost of ride comfort, but unlike some vehicle developments, as power and speed have increased, the noise and vibration within the hovercraft have steadily decreased. The sources of noise and vibration are discussed, together with possible methods of reduction in order to improve crew and passenger comfort.

72—680

THE LOCATION OF THE GROUND FOCUS LINE PRODUCED BY A TRANSONICALLY ACCELERATING AIRCRAFT
Nicholls, J.M. and James, B.F.
(Meteorological Res. Flight, Royal Aircraft Estab., Farnborough, Hampshire, England)
J. Sound and Vib. 20(2), 145-167
(Jan. 22, 1972)19 refs

Key Words: sonic boom

The theory of propagation of a sonic bang in a horizontally stratified atmosphere with wind is described. The theory is utilized to derive a computer program for finding, for an aircraft climbing and accelerating (normally along a straight line ground track), the location of the intersection of the bang wave front with the ground. The locations of the ground focus line, along which there is a marked enhancement of the bang "overpressure" on the ground, are found for a large range of atmospheric structures. The feasibility of forecasting these locations, and the possibility of defining an area on the ground which would encompass all focus lines for a given flight plan, are also examined.

72—681

A NEW BASIS FOR AIRCRAFT NOISE RATING
Robinson, D.W. (Envir. Unit, Natl. Phys. Lab., Teddington, England)
23 pp (Mar. 1971)

Key Words: aircraft noise, noise measurement

Starting with the definition of a noise pollution level, the authors show that the incremental value of this quantity due to the occurrence of an aircraft noise provides a logical basis for rating the noise. This measure has simple additive properties which permit the same definition to be extended to an arbitrary series of events, including the background noise and its fluctuations. By specifying reference values of certain parameters, a formula is evolved which is suitable for aircraft certification purposes; the relation of this measure to effective perceived noise level is discussed.
N72-10035

72—682

THE DESIGN OF THE U.S. SST FOR LOW COMMUNITY NOISE
Vachal, J.D. and Florsheim, B.H.
(The Boeing Co.)
SAE Paper No. 700508 (Oct. 5-9, 1970)
3 refs

Key Words: aircraft noise, noise reduction

The need for achievement of low community noise levels has had a major influence on the configuration selected for the United States Supersonic Transport (Boeing 2707-300). The selection and development of design features which affect community noise are presented. The configuration has a relatively large span delta wing of moderate sweep and wing loading with full span leading and trailing edge flaps. An all moving horizontal tail with geared flap is used for trim and control. The use of an unusually far aft center of gravity range is achieved through a full-time stability augmentation system. All of these design features contribute to low drag at high lift, resulting in high takeoff performance and low levels of thrust required during flight over the community during both takeoff and landing. The resulting airplane has the versatility to use operational techniques which further reduce noise. Noise characteristics of various power plant types are not treated, but the effect on noise of engine-airframe matching is discussed.

72—683

METROPOLITAN AIRCRAFT NOISE ABATEMENT POLICY STUDY: CAPE KENNEDY REGIONAL AIRPORT, MELBOURNE, FLORIDA
(E. Central Fla. Regional Planning Council, Winter Park, Fla.)
134 pp (June 1971)

Key Words: aircraft noise, noise reduction

An analysis of the relationship between noise generated by aircraft operations and the use of affected land surrounding the airport in Melbourne, Florida, is presented. Current land use information and the prospects for change are included. Proposals to encourage and enable the local governments involved to achieve compatible development through cooperative intergovernmental measures are developed. These include: comprehensive planning, capital improvement programing, mapping, zoning, annexation, and land acquisition. The ecological impact is considered in a separate section.
N72-10050

72—684

AVIATION NOISE EVALUATIONS AND PROJECTIONS -- SAN FRANCISCO BAY REGION
(Assoc. Bay Area Gov., Berkeley, Calif.)
151 pp (Aug. 1971)

Key Words: aircraft noise

The effects of aviation noise upon the region, which can be used as guidelines to develop a regional airport systems plan are presented. Certain assumptions as to future runway utilization aircraft types, and airport use are necessary for this study effort. The NEF noise environment analysis procedure selected represents the best knowledge at this time of aviation-generated noise and its impact upon human activities.
PB-204035

BIOENGINEERING

72—685

EFFECTS OF MECHANICAL VIBRATIONS ON THE GROWTH AND DEVELOPMENT OF MOUSE EMBRYOS
Bantle, J.A. (E. Mech. Univ., Ypsilanti, Mich.)
Aerosp. Med. 42, 1087-1091 (Oct. 1971)

Key Words: biological organisms, vibration response

The critical acceleration levels, nature of the damage caused, and days of gestation most susceptible to vibration-induced damage in mouse embryos are investigated. The results indicate that the mouse embryo is resistant to vibration injury. There are indications that mechanical vibrations at certain frequencies and accelerations could be teratogenic. The major adverse effect seems to act upon the growth process through inhibition of cell division. This was demonstrated by significantly shorter lengths and lower weights of embryos subjected to vibration.

72—686

ARTERIAL BLOOD FLOW AND BLOOD PRESSURE IN ANIMALS UNDER MECHANICAL VIBRATION
Edwards, R.G.
96 pp (1970)

Key Words: biological organisms, vibration response

Mechanical models of the left ventricular action and of the circulatory system are constructed and exposed to sinusoidal mechanical vibration. The purpose is twofold, namely: (1) to set up and check out the instrumentation required to monitor blood flow rate and pressure during vibration; and (2) to obtain an indication of the magnitudes and mechanisms by which vibration affects these quantities and to compare the results to those predicted from an existing mathematical model. Electromagnetic flow transducers are chronically implanted around the aorta and the pulmonary and carotid arteries of dogs. After recovery each of three anesthetized animals is exposed in an upright position (spine vertical) to 30 sec of vibration, in the direction of the gravity vector, at 2 to 12 Hz and at 1 to 3 G acceleration amplitude. During the tests blood flow rate and arterial pressure (via acutely positioned catheter-tip pressure transducers) are monitored, and in addition the force transmitted between animal and vibration exciter is measured. Maximum and minimum peak flow rates, pressure, and transmitted force during vibration as compared to normal function are determined.
UM 71-19,364

72—687

THE VIBRATORY PATTERN OF THE ROUND WINDOW IN CATS
Khanna, S.M. and Tonndorf, J. (Fowler Memorial Lab., Dept. Otolaryngology, Columbia Univ., New York, N.Y.)
J. Acoust. Soc. Am. 50(6), 1475-1493 (Dec. 1971) 10 refs

Key Words: bioengineering, biological organisms, holographic techniques

Round window displacements are recorded by means of time-averaged holography in live cats and in fresh anamal cadaver specimens. Considerable technical difficulties had to be overcome first, before such recordings became feasible. In the majority of cases, the displacement pattern is complex, even at low frequencies, with the maximum displacement occurring in the anterio-superior region. Variations between animals are relatively large. Inner ear impedances are in the low megohm range; in this respect the results confirm those of an earlier study from this laboratory. However, while in cadaver specimens the results are reasonably uniform, in live animals impedance appears to increase with exposure to high SPLs. This increase in impedance appears to exert a protective function for the inner ear.

BRIDGES

72-688

DYNAMIC RESPONSE OF SKEWED GIRDER BRIDGES TO MOVING LOADS
Eka, U.J.U.
PhD Thesis, McGill Univ. (1971)

Key Words: bridges, computer programs, dynamic response, moving loads

A numerical method and computer program developed for the analysis of skewed girder highway bridges under static and dynamic loads are presented. Both the finite element and finite difference techniques are used in the solution of the problem. The bridge is idealized as an assembly of finite flat plate and beam elements. The vehicle is idealized as a single-axle sprung load having one wheel. Damping, which is not considered in the bridge, is taken into account in the motion of the vehicle. The finite element method is used to derive the system matrixes (mass and stiffness) of the structure. Equilibrium equations are written and solved by different techniques, depending on the type of loading on the structure. Experimental results obtained from tests conducted on three bridge models having skew angles of 0, 30, and 60 deg compare favorably with theoretical predictions.
UM (order from Natl. Library of Canada at Ottawa)

BUILDINGS

72-689

STEEL SEISMIC DESIGN
Butcher, G.W. (Morrison, Cooper and Partners, Consulting Engineers, Wellington, New Zealand)
New Zealand Engr. 26(11), 321-340 (Nov. 15, 1971) 31 refs

Key Words: multistory buildings, seismic design

Structural steel has proved to be a suitable material for ductile moment-resisting space frames in buildings subjected to strong earthquake ground motions. The material properties considered necessary to avoid premature failure before the beneficial inelastic potential of the material is achieved are discussed. Consideration is also given to low cycle fatigue, connections, design methods, workmanship and inspection.

72-690

MECHANICALLY INDUCED VIBRATION IN BUILDINGS
Monk, R.G. (Acoust. Tech. Ltd.)
Envir. Engr. 51, 9-12 (Dec. 1971) 3 refs

Key Words: human factors engineering, machinery, structural response, vibration excitation

Mechanically induced vibration in buildings with particular reference to vibration caused by industrial plant and machinery, is discussed. Some perspective is given to the orders of magnitude of vibration likely to be produced by most industrial plants in relation to other sources of vibration, such as earthquakes and pile driving Structural and human response are dealt with in some detail.

72-691

COMPARISON OF CALCULATED AND MEASURED RESPONSE OF A HIGH-RISE BUILDING TO GROUND MOTIONS PRODUCED BY UNDERGROUND NUCLEAR DETONATIONS
Tokarz, F.J. and Bernreuter, D.L. (Lawrence Radiation Lab. Calif. Univ., Livermore, Calif.)
34 pp (Dec. 23, 1970)

Key Words: dynamic response, ground motions, multistory buildings, nuclear explosions, underground explosions

The dynamic response of the Bank of Nevada building in Las Vegas to ground motions resulting from several underground nuclear detonations

at the Nevada Test Site is investigated. The events chosen are Handley, Benham, Jorum, and Boxcar. Both a time-dependent analysis, using the modal superposition method, and a spectral response analysis are presented and a brief outline of both methods is included. The ground motion is measured at the base of the building and at NOAA-NOS seismic stations designated as SE6 and Squires Park. Measured time-history records are used as the exciting motion inputs for the analyses. The peak response of the roof of the building is also measured for each event. In addition, for the Handley Event the time-history response is measured at various levels of the building. A comparison is made between the calculated and measured peak responses and between time-history responses. The sensitivity of the response calculations to three factors is studied: the mathematical model of the building, the input ground motions, and the value of viscous damping. The results indicate: (1) that reasonable modeling assumptions can lead to models whose calculated response is quite different from the measured response: (2) when measured ground motions as near as 800 m from the building are used for the exciting motion, the calculated and measured response values are different; and (3) when a posteriori information of the building (e.g., mode shapes, fundamental periods, and damping) is used, it is possible to develop a model whose calculated response agrees well with the recorded time-history response of the building.
NSA-212

CABINETS

72—692

RESPONSE OF ELECTRONIC CABINETS EXCITED BY A FAST SINE SWEEP
Short, S.A. and McMunn, J.C. (TRW Syst. Group)
SAE Paper No. 700846 (Oct. 5-9, 1970)
5 refs

Key Words: dynamic response, equipment response, shock response

The dynamic response of an electronic cabinet subjected to an amplitude-modulated fast sine sweep is presented. The fast sine sweep is synthesized to have a prescribed response spectra. The cabinet is modeled as a multidegree-of-freedom system in each of three orthogonal directions and the dynamic response is computed using mode superposition. The analytical and experimental results are compared and the agreement is shown to be good.

CONSTRUCTION

72—693

STATIC AND DYNAMIC SHEAR BEHAVIOR OF UNIFORMLY LOADED REINFORCED CONCRETE DEEP BEAMS
Crist, R.A., Jr.
271 pp (1971)

Key Words: beams, dynamic testing, reinforced concrete

Behavioral equations for reinforced concrete deep beams, especially in the realm of shear capacity, are developed. A series of static and dynamic beam tests is reported. Dynamic shear behavior equations for deep beams are derived on the lower boundary of data represented by research from this report and other research comprising 12 dynamic tests. Equations for a total dynamic shear capacity for a first cycle loading are given which conservatively predict shear capacities of the beam tests considered. Web reinforcing capacity is considered where the web reinforcing capacity is an orthogonal array of reinforcing coincident with the longitudinal axis of a beam. Dynamic flexural response indicates that plane sections prior to bending do not remain plane after bending. In this type of dynamic test nonplanar sections must be accounted for in the moment of resistance calculations for deep beams in the strain hardening region. Natural periods of vibration are calculated for the deep beams. Using the assumption of an equivalent single degree-of-freedom system and calculating the natural period from the measured dynamic beam response give reasonable results compared to the natural period calculated by an energy method using measured beam properties.
UM 72-4004

ELECTRICAL

72—694

CALCULATION OF ACOUSTIC POWER RADIATED BY AN ELECTRIC MACHINE
Ellison, A.J. and Yang, S.J. (Dept. Elec. and Electron. Engr. Queen Mary Col., Univ. London, England)
Acustica 25 (1), 28-34 (July 1971) 15 refs

Key Words: machinery, noise

Methods are presented for calculating the noise power radiated as a result of surface vibrations of an electric machine having any length-diameter ratio. The analytical results taking account of

the phase angle between the sound pressure and the particle velocity and the approximate farfield results are verified by comparison with measured results.

HUMAN
(Also see Nos. 577, 684)

ISOLATION
(Also see No. 733)

72—695
ELASTOMERIC SUSPENSIONS WITH GEOMETRIC SPRING RATES FOR OFF-HIGHWAY VEHICLES
McClelland, J.E. (Dynafloat Div., Unit Rig & Equip. Co.)
SAE Paper No. 700738
(Sept. 14-17, 1970) 10 refs

Key Words: elastomers, off-highway vehicles, springs, suspension systems

An off-highway vehicle suspension using direct cushioning pads made of modular elastomer bonded to metal is described. The pads are stacked inside telescoping struts which are connected between the axle and the frame. The rheology of the elastomer, and the cross-sectional shape of the pads give a geometric load vs deflection curve; a near-linear spring rate vs load curve, and a near-constant frequency at any level of load. These characteristics limit excessive deflections and increase the stability and controllability of the vehicle. The pads are self-damping, dissipating a large percentage of the applied energy, and require no auxiliary shock absorbers. A wide range of spring and damping functions are possible by utilizing different elastomers, pad shapes, sizes, and numbers of pads. Initial cost and weight are less than conventional springs and struts. Maintenance costs are negligible and service lives of more than 25,000 operating hours have been recorded between overhauls.

72—696
AIR RIDE TRUCK SUSPENSION
McLean, A.D. (Kenworth Motor Truck Co., Div., Pacific Car & Foundry Co.)
SAE Paper No. 700894 (Nov. 4-6, 1970)

Key Words: suspension systems, trucks

The use of air spring suspensions in the rear of truck chassis is discussed.

72—697
DYNAMIC RESPONSE TESTS OF AN AIR CUSHION SUSPENSION SYSTEM FOR THE LINEAR INDUCTION MOTOR OF THE TRACKED AIR CUSHION RESEARCH VEHICLE
Meiselholder, S.G.; Graham, H.R.; and Birchill, J. (TRW Syst. Group, Redondo Beach, Calif.)
293 pp (July 1971)

Key Words: dynamic response, ground effect machines, suspension systems

The results of a test program to determine the dynamic response characteristics of an air cushion suspension system are presented. The air cushion and secondary suspension are designed for the support and guidance of the linear induction motor on the 300 mph tracked air cushion research vehicle. The tests simulate the motion of the suspension system on the vehicle moving over a guideway with sinusoidal surface irregularities. The test variables include: oscillatory excitation amplitude, air supply system admittance, air cushion skirt configuration, and reaction rail flexibility. Test results are compared to theoretical response predictions for both the linear induction motor support and guidance systems.
PB-204440

MATERIAL HANDLING

72—698
BASIC RESEARCH IN DYNAMIC SEALING
Fisher, C.F., Jr.; Stair, W.K.; Brooks, C.R.; Edmondson, A.J. and Blalock, T.V. (Dept. Mech. Aerosp. Engr. Tenn. Univ., Knoxville, Tenn.)
62 pp (Oct. 1971)

Key Words: dynamic testing, seals (stoppers), test facilities

Progress and significant technical information obtained recently on basic research in dynamic sealing are outlined. Progress on construction of a dynamic test facility for mechanical face seals is reported. Results of a mathematical study, including inertia effects, of turbulent flow in the space between the faces of mechanical seals is reported. Results of theoretical and experimental studies of flow between porous disks is reported.
AD-732021

MECHANICAL

72-699
A TECHNIQUE FOR REDUCTION OF AXLE GENERATED NOISES
Hajduk, D. (Cadillac Motor Car Div., Gen. Motors Corp.)
SAE Paper No. 700102 (Jan. 12-16, 1970)

Key Words: automobile axles, natural frequency, noise reduction

Vehicle axle noise resulting from the resonant vibration of rear suspension and driveline components is measured and reduced by changing structural properties. No changes are made to the rear axle assembly to achieve the noise reductions. Mesh frequency and twice mesh frequency response measurements of the rear control arms, axle housing, and propeller shaft correlate exactly with vehicle noise periods. Structural stiffness and mass changes to these components with the effect on noise and vibration response is presented. A description of the eventual production hardware which attenuates axle noise to an acceptable level is also presented.

OFF-ROAD VEHICLES
(Also see No. 695)

72--700
ASPECTS OF THE DEVELOPMENT OF A TEST CODE FOR TRACTOR SUSPENSION SEATS
Stayner, R.M. (Natl. Inst. Agric. Engr., Wrest Park, Silsoe, Bedford, England)
J. Sound and Vib. 20(2), 247-252 (Jan. 22, 1972) 4 refs

Key Words: human factors engineering, standards and codes, suspension systems, tractors

Factors which affect the performance of suspension seats used to improve the ride of agricultural tractors are considered with reference to the development of an international test code.

PACKAGE

72-701
CONTAINER DEVELOPMENT CONCEPTS FOR IMPROVED RESISTANCE TO THE DYNAMIC ENVIRONMENT
Berger, S.; Schaeffer, H.G.; and Weis, J.P. (Cont. Syst. Res. Inc., Arlington, Va.)
108 pp (Oct. 1971)

Key Words: cargo vehicles, computer programs, containers, dynamic testing, testing techniques

A series of tasks on the continuing problem of container development for improved resistance to service conditions in the transport and handling environment is reported. This environment is characterized by high-intensity transient loads that occur with enough frequency to preclude a position that such loads are abnormal. The initial task takes up service simulation for test and evaluation which includes environmental measurements, test methods, and a recommendation for dynamic testing. In order to plan dynamic testing in detail a full comprehension of the effects of impact loads is required and an analysis is reported in which beam strips are used as an element of a container panel. The results of the analysis contribute to understanding current performance and selection of test articles for panel development. A test fixture (essentially a container frame to which demountable test panels can be fixed) is proposed.
AD-732491

72--702
MATHEMATICAL MODEL FOR PREDICTION OF MAXIMUM DAMAGE TO SHIELDED SHIPPING CONTAINERS
Donham, B.J. (Los Alamos Sci. Lab., New Mex.)
From Seminar Tests on Transport Packaging for Radioactive Materials, Vienna, Austria (Feb. 8, 1971), 14 pp

Key Words: containers, damage prediction, drop tests, mathematical models, shipping containers

The damage to a shipping container for radioactive materials resulting from a 30 ft free fall is mathematically predictable by application of a new method. The method treats the cylinder as a number of discrete elements with dynamic properties which are varied to simulate the changing geometry of the cylinder as it deforms. Experimental proof of the calculation is obtained by dropping lead cylinders from a prescribed

height and comparing the results with those predicted by the calculation. Theoretical and experimental results were in sufficiently close agreement for the method to be considered valid for establishing upper limits of expected damage.
NSA-51835

72—703

DESTRUCTIVE TESTS RELATED TO DEVELOPMENT OF LMFBR FUEL SHIPPING CASKS
Irvine, A.R.; Shappert, L.B.; Evans, J.H.; and Davis, F.C. (Oak Ridge Natl. Lab., Tenn.)
From Seminar Tests on Transport Packaging for Radioactive Materials, Vienna, Austria (Feb. 8, 1971) 15 pp

Key Words: drop tests, energy absorbers, impact tests, tanks (containers)

Models of steel-shielded cask structures, all-metal cask closures, and impact energy absorbers, destructively tested in one phase of an LMFBR fuel shipping cask development program, are evaluated. Various scale models of a large steel cask are impact tested and, with the exception of a very small unit, behave in a generally proportional manner. A 30 ft free-fall impact test with unprotected steel specimens produces only external deformation; there is no evidence of any change in internal volume or of cracks or fissures. Scale models of an all-metal seal, mounted in a 1/6-scale steel cask, and subjected to a 30 ft free-fall impact test in which deceleration forces are as high as 2300, are described. The very low initial leak rate is increased only slightly by the test. Fins and a tube-in-tube energy absorber are tested to determine performance characteristics. The tube-in-tube energy absorber has no preferred direction for loading, can be made in large sizes to produce low decelerations, and has no sharp peaks in its loading curve.
NSA-51840

72—704

TESTING A SHOCK ABSORBER OF UNIQUE DESIGN TO DEMONSTRATE THAT A TYPE B PACKAGING WOULD PASS THE FREE DROP TEST
Rollins, J.D and Evans, J.H. (Nuclear Fuel Serv. Inc., Rockville, Md.)
From Seminar Tests on Transport Packaging for Radioactive Materials, Vienna, Austria, (Feb. 8, 1971) 10 pp

Key Words: drop tests, packaging, shock absorbers, shock testing

An extensive series of drop tests performed on both isolated and package-attached shock absorbers of a newly-conceived tube-in-tube design is presented. The experimental methods used in the tests are described and results are interpreted based on experimental observation and analytical corrections made available through computer reduction of data instrumentally recorded during the tests. The ability of Type B packaging to pass the free-drop test successfully through the use of an ancillary shock absorption device is demonstrated. The device is simple and inexpensive to fabricate, and effectively absorbs energy while adding insignificantly to the overall volume and weight of the packaging system. The effects of various shock absorber design parameters on energy absorption capability are evaluated.
NSA-51836

72—705

STRUCTURAL DYNAMIC ANALYSIS OF ELECTRONIC ASSEMBLIES USING NASTRAN RESTART/FORMAT CHANGE CAPABILITY
Schmitz, R.P. (Sperry Rand Corp., Space Support Div., Huntsville, Ala.)
Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 28 pp, 3 refs

Key Words: computer programs, dynamic response, equipment response, finite element technique, NASTRAN

The NASTRAN program is applied to the determination of the structural dynamic response of an electronic packaging and support structure. The structure modeled and analyzed is the experiment support system assembly of the SKYLAB Orbital Workshop. The analysis uses three rigid formats: eigenvalue analysis frequency response and static analysis. The same model is used for each analysis using NASTRAN's checkpoint/restart format change capability. Geometry plotting and xy plotting are used to illustrate the mode shapes and acceleration response.

72—706

METHODS OF DETERMINING COMPLIANCE OF TYPE B PACKAGES WITH THE THERMAL AND MECHANICAL REGULATORY REQUIREMENTS
Shappert, L.B.; Evans, J.H.; and Stoddart, W.C. (Oak Ridge Natl. Lab., Tenn.)
From Seminar Tests on Transport Packaging for Radioactive Materials, Vienna, Austria (Feb. 8, 1971) 20 pp

Key Words: damage prediction, packaging, radioactive materials, shipping containers

The IAEA Regulations require radioactive material shipping packages to meet certain performance requirements. The designer must determine what methods are available and applicable to his package design. Generally, the most difficult conditions to meet are those imposed by the accident requirements, namely, the 9 m impact and the 30 min fire. Impact data are correlated so that, in at least some cases, damage may be predicted empirically. In the absence of such information, scale models may be dropped, and the gross damage to the prototype may be predicted from the damage to the model. A comparison of the response to both a uranium-shielded cask and a steel-shielded cask to the 30 min and 4 m fires indicates that the steel cask is capable of maintaining significantly lower temperatures in the extended fire. Thermal stresses in massive cask walls are found to be significant, and a computer program that is available to study them is discussed.
NSA-51834

72—707

DROP IMPACT TEST ON A SPENT-FUEL SHIPPING CASK
Shimamura, S., et al (Japan Soc. Mech. Engr. Tokyo, Japan)
From Seminar Tests on Transport Packaging for Radioactive Materials, Vienna, Austria (Feb. 8, 1971) 12 pp

Key Words: drop tests, impact tests, packaging, radioactive materials, shipping containers

The drop impact test on a spent-fuel shipping cask carried out in Japan in 1968 is described. The drop test facility, designed on the basis of the IAEA Regulations, conforms to the following specifications: maximum test weight of 10 tons; maximum drop height of 9 m; target -- a reinforced concrete block of 6 m x 6 m x 2.5 m with a steel plate of 12.5 mm thickness on the upper surface. The prototype cask was a horizontal cylinder weighing 80 tons. The decelerations at the moment of drop impact are measured with an accelerometer mounted on the top surface of the models. Deformations in these models due to the drop impact are also observed. In addition, high-speed cinematography is used to determine the motion of the models during the tests.
NSA-51838

72—708

TESTS ON A SPENT-FUEL SHIPPING CASK IN JAPAN
Aoki, S. (Tokyo Inst. of Tech., Tokyo, Japan)
From Seminar Tests on Transport Packaging for Radioactive Materials, Vienna, Austria (Feb. 8, 1971) 8 pp

Key Words: drop tests, impact testing, nuclear reactors, shock absorbers, shock testing, testing techniques, test models

Experimental studies carried out under accidental conditions to obtain necessary design data for shipping casks for transporting large amounts of spent fuel from nuclear power stations in the near future are reported. Drop impact tests of spent-fuel shipping casks are described.
NSA-51837

72—709

PACKAGING YOUR PRODUCT
Engr. Matl. Design 15 (1), 27-28 (Jan. 1972)

Key Words: energy absorption, packaging

Methods of packaging for varied environments are discussed. Available materials and concepts are shown.

PUMPS, TURBINES, FANS, COMPRESSORS

72—710

DISCRETE FREQUENCY NOISE FROM LIFTING FANS
Abdelhamid, A.N. (Carleton Univ., Ottawa, Canada)
J. Engr. Power, Trans. ASME 93 (4), 431-440 (Oct. 1971) 19 refs

Key Words: aerodynamic excitation, fans, frequency response, rotary wings

Discrete frequency noise characteristics of a research lifting fan are investigated. Unsteady aerodynamic forces [illegible] on the rotor and stator blades are calcu[illegible]ng the results of previous investigators a[illegible] an analysis which determines the effect of fluctuating velocity disturbance parallel to blade chord on the unsteady lift of cambered thin airfoils. These forces are then used to determine the characteristics of discrete frequency noise emission from the fan. It is shown that the rotor interaction noise dominates the fan noise. Predicted sound pressure levels are compared with experimental observations and good agreement. Possible means of reducing lifting fan noise are discussed.

72—711

FAN-COMPRESSOR NOISE: PREDICTION, RESEARCH, AND REDUCTION STUDIES
Burdsall, E.A. and Urban, R.H. (Pratt and Whitney Aircraft, E. Hartford, Conn.)
395 pp (Feb. 1971)

Key Words: compressor blades, fans, mathematical models, noise prediction

Fan and compressor noise is studied to develop an accurate prediction system to enable the selection of proper acoustical design choices for future engines. Experimental programs are conducted using a variety of test rigs to provide acoustic data and to validate theoretical concepts. Mathematical models are developed for each type of fan noise, and their applicability to actual engines is evaluated.
AD-733590

72—712

SHOCK WAVE BEHAVIOR IN TRANSONIC COMPRESSOR NOISE GENERATION
Fink, M.R. (Aerodyn., United Aircraft Corp. Res. Labs., E. Hartford, Conn.)
J. Engr. Power, Trans. ASME 93 (4), 397-403 (Oct. 1971) 12 refs

Key Words: compressor blades, noise (sound)

Compressor noise at transonic tip speeds contains strong tones at multiples of shaft rotation frequency in addition to harmonics of blade passage frequency. Nonlinear first-order theory is utilized to determine shock wave decay with upstream distance. In the extreme nearfield of the rotor, shock strength varies inversely as the square root of upstream distance from the blade leading edge. Further upstream, the expansion region from the neighboring blade in the cascade interacts with the shock so that shock strength varies as the inverse first power of distance. These aerodynamic results are used to infer some characteristics of transonic compressor noise. These are compared with experimental results.

RAIL

72—713

AN ACTIVE SUSPENSION SYSTEM DESIGN FOR THE LATERAL DYNAMICS OF A HIGH-SPEED WHEEL-RAIL SYSTEM
Sarma, G.N. and Kozin, F. (Elec. and Electron. Engr., Birla Inst. Tech. Sci., Pilani, India)
J. Dyn. Syst. Meas. and Control, Trans. ASME 93 (4), 233-241 (Dec. 1971) 19 refs

Key Words: active isolation, high-speed ground transportation, lateral response, railroad trains, suspension systems

To solve some stability problems, an active suspension system is studied for the high-speed rail vehicle and is compared with the passive system. The vehicle control problem is formulated as an optimization problem with an integral quadratic cost function. The feedback law thus obtained is further simplified. For truck dynamics, with external controllers, a Lyapunov function approach is taken for considering state constraints. Analog computer simulation is used for stability regions.

72—714

DYNAMIC RESPONSES OF RAILROAD CAR MODELS TO VERTICAL AND LATERAL RAIL INPUTS
Sewall, J.L.; Parrish, R.V.; and Durling, B.J. (NASA-Langley Res. Ctr., Langley Station, Va.)
NASA-TN-D-8375, 97 pp (Nov. 1971)

Key Words: dynamic response, high-speed ground transportation, mathematical models, railroad trains

Simplified dynamic models applied in a study of vibration in a high-speed railroad car are described. A 4 degree-of-freedom model for vertical responses to vertical rail inputs and a 10 degree-of-freedom model for lateral response to lateral or rolling (cross-level) inputs from the rails are used. Elastic properties of the passenger car body are represented by bending and torsion of a uniform beam. Rail-to-car (truck) suspensions are modeled as spring-mass-dashpot oscillators. Lateral spring nonlinearities approximating certain complicated truck

mechanisms are introduced. The models are excited by displacement and in some cases velocity inputs from the rails by both deterministic (including sinusoidal) and random input functions. Results are obtained both in the frequency and time domains. Solutions in the time domain for the lateral model are obtained for a wide variety of transient and random inputs generated on-line by an analog computer. Variations in one of the damping properties of the lateral car suspension gives large fluctuations in response over a range of car speeds for a given input. This damping coefficient is significant in reducing the higher lateral car responses for nonlinear springs for three different inputs.
N72-10964

REACTORS

72—715

NONLINEAR SEISMIC RESPONSE OF A REINFORCED CONCRETE NUCLEAR REACTOR CONTAINMENT VESSEL
Citerley, R.L. and Ball, R.E. (Anamet Labs., Inc., San Carlos, Calif.)
Nuclear Engr. Design 17(3), 341-344 (1971) 9 refs

Key Words: dynamic response, nuclear reactor components, reinforced concrete, seismic response, shells of revolution

The geometrically nonlinear, dynamic response of a reinforced concrete shell of revolution subjected to a horizontal acceleration at the base is examined. The results from a numerical example indicate that the nonlinear effects are negligible and motion in the ovalling mode of the vessel is insignificant.

72—716

EARTHQUAKE PROTECTION FOR NUCLEAR REACTORS
Hentschel, G.; Novak, W.; and Orth, F.
23 pp (May 1971)

Key Words: nuclear power plants, seismic design

The design features of a rocking support for nuclear power plant structures are described. Application of this support concept to an earthquake resistance plant with a gas cooled high temperature reactor is discussed.
NSA-54151

72—717

ON THE REPRODUCIBILITY OF THE PARALLEL-FLOW INDUCED VIBRATION OF FUEL PINS
Kadlec, J. and Ohlmer, E. (Institut für Reaktorentwicklung, Kernforschungszentrum Karlsruhe, Karlsruhe, Germany)
Nuclear Engr. Design 17(3), 355-360 (1971) 6 refs

Key Words: fluid-induced vibrations, nuclear reactor components

The influence of the test loop on parallel flow induced vibration of fuel pins of the Na 1 fast reactor design is investigated. The experiments are performed with the same subassembly mockup, mounted in the test section of four different flow loops with several modifications. In spite of a broad variation of the level (1:10) and the structure of pressure fluctuations at the water inlet into the subassembly, only moderate scatter (± 50 percent) of the level and a slight variation of the structure of the vibrating response of the pins is observed. Experimental results are presented in the form of diagrams of normalized root mean square values of pressure fluctuations and vibration strains plotted over the Reynolds number. The structure of pressure fluctuations and vibration strains is illustrated by several typical spectral density plots.

RECIPROCATING MACHINE

72—718

WHIRLING OF A FOUR-CYLINDER ENGINE CRANKSHAFT
Brown, R.K. and Mischke, C.R. (John Deere Waterloo Tractor Works)
SAE Paper No. 700121 (Jan. 12-16, 1970) 16 refs

Key Words: crankshafts, whirling

Crankshaft strains and the deviation of flywheel motion from plane rotation about the axial centerline of the main bearing bores are measured in a four cylinder, four stroke, Otto cycle in-line engine with three main bearings. The crankshaft is run with a 50 lb-ft and a 127 lb-ft flywheel at 0.006 and 0.008 in. diam main bearing clearance over a range of 2000 to 3000 rpm engine speed under no-load conditions. The flywheel exhibits a first-order, forward whirl for all test conditions. Crankshaft stresses are not significantly affected by either the flywheel mass or the main bearing clearances.

ROAD

(Also see Nos. 581, 696)

72—719

CHRYSLER ENERGY ABSORBING, ANTITHEFT STEERING COLUMN
Adams, D., III and Cassle, R.S. (Chrysler Corp.)
SAE Paper No. 700001 (Jan. 12-16, 1970)
4 refs

Key Words: automobile steering columns, energy absorption

A new energy absorbing steering wheel and antitheft steering column are described. Both fulfill Federal Safety Standards required for 1970 cars. Steps in the development of these two items are outlined and special features and performance characteristics are discussed.

72—720

A THREE-DIMENSIONAL COMPUTER SIMULATION OF A MOTOR VEHICLE CRASH VICTIM -- PHASE I: DEVELOPMENT OF THE COMPUTER PROGRAM
Bartz, J.A. (Cornell Aeronaut. Lab., Inc., Buffalo, N.Y.)
343 pp (July 1971)

Key Words: automobiles, collision research, computer programs, simulation

A digital computer program to simulate a vehicle crash victim, either occupant or pedestrian, in three dimensions is currently under development. The dynamics model of 40 degrees-of-freedom consists of 15 rigid body segments connected by ball-and-socket and pinned joint and includes spring and dissipative torques at the joints to simulate muscle tone. Provision is made within the formulation to alter the number of segments and joints of the model. A contact model simulates external forces acting on the crash victim, including forces caused by contact with vehicle surfaces, between body segments, and restraint forces from both belt and inflatable types of restraint systems. A graphics display model produces orthogonal views of the victim from both an off-line plotter graphics routine and a simplified printer graphics display. An injury criteria model provides a means for assessing the degree of injury sustained by the simulated crash victims.
PB-204172

72—721

COMPUTER PROGRAM FOR AN AIR BAG RESTRAINT SYSTEM
Dufort, R.H. (Cornell Aeronaut. Lab., Inc., Buffalo, N.Y.)
84 pp (Sept. 1971)

Key Words: air bags (safety restraint system), automobiles, computer program

A simulation model developed to provide an analytical tool for rapidly and inexpensively exploring the approximate performance of an air bag system is described. Acceleration and rebound of the impacting body are the principal measures of performance; how they are influenced by system design variations are the principal results. Typical design parameters which can be evaluated are: inflation pressure, bag size, gross bag shape, vent area, vent actuation pressure, etc. The basic model air bag consists of a fabric type container having a cylindrical center section with hemispherical ends. A rigid body, corresponding to the size and weight of the torso of a vehicle occupant, is assumed to impact the air bag at the center and normal to the longitudinal axis. A deformed shape profile is postulated which maintains the longitudinal section periphery and the cross section contour lengths constant and equal to their initial values. All output parameters are provided as functions of time. These include acceleration, velocity, displacement, internal pressure, volume, pressure-force area, gas flow and residual gas weight. The equations and flowcharts, which describe the model are included. A program listing in BASIC + is presented, as are examples for the solution of cylindrical and customized air bags.
PB-204170

72—722

VEHICLE TRAJECTORIES AFTER INTERSECTION COLLISION IMPACT
Emori, R.I. and Tani, M. (Univ. Calif. Los Angeles, Calif.)
SAE Paper No. 700176 (Jan. 12-16, 1970)
5 refs

Key Words: automobiles, collision research

The postcollision motion starts immediately upon completion of a collision impact where the vehicles obtain new sets of velocities through an exchange of momentum. Similitude with model study and full-scale automobile experiments indicate that the postcollision trajectory is essentially a plane motion, governed by inertia and tire friction. Trajectories depend on

many parameters (such as tire friction coefficient, front wheel steering angle, vehicle geometrics, and whether wheels are locked or free to rotate) but not on the vehicle weight. Theoretical computations of trajectories are compared with experiments.

72—723

VEHICLE MECHANICS OF INTERSECTION COLLISION IMPACT
Emori, R.I. (Univ. Calif., Los Angeles, Calif.)
SAE Paper No. 700177 (Jan. 12-16, 1970)
9 refs

Key Words: automobiles, collision research

There are two phases in automobile collisions, namely, the impact, and the postcollision. As indicated by full-scale experiments in unidirectional collisions, and as confirmed by similitude model study in side impact collisions, vehicles behave as rigid bodies in both phases. The analyses of seemingly complex intersection automobile collision phenomena are possible by application of two-dimensional impact theories which are primarily based on the momentum-impulse principle of rigid bodies. Available full-scale intersection experiments indicate the numerical range of the coefficient of restitution and the coefficient of friction between two vehicle bodies in collision.

72—724

APPLICATION OF AEROSPACE DATA ANALYSIS TECHNIQUES TO AUTOMOTIVE CRASH SAFETY PROBLEMS
Kelly, R.D.
SAE Paper No. 700843 (Oct. 5-9, 1970)
7 refs

Key Words: automobiles, collision research

The potential value of several data analysis techniques to aid in the solution of crash safety problems is discussed. Each technique is illustrated by application to acceleration measurements from passenger vehicle crash tests.

72—725

SECOND GENERATION ENERGY ABSORBING COLUMN WITH LOCKING FEATURE
Marquis, D.P. (Saginaw Steering Gear Div., Gen. Motors Corp.)
SAE Paper No. 700002 (Jan. 12-16, 1970)

Key Words: automobile steering wheels, energy absorption

A 1969 steering column design which involves a system for absorbing energy from the body of the driver in the event of a frontal collision is described. This column also contains a locking system which permits the locking of steering shaft, gear shift, and the ignition switch. A description of the inhibiting system is included.

72—726

RIDE RESPONSE OF A MODEL VEHICLE TO HARMONIC INPUTS
McCallan, D.M. (Davidson Lab., Stevens Inst. Tech., Hoboken, N.J.)
199 pp (May 1971)

Key Words: ground vehicles, harmonic excitation, lumped parameter method, test models

Vehicle response to harmonic inputs is examined. The theories of mechanical vibrations and linear systems analysis are applied to one, two and n-dimensional lumped-parameter systems to develop an orientation to the methods of obtaining theoretical system responses. Emphasis is placed on the system transfer function, the frequency and characteristic polynomials, and the steady state response. Subsequently, the theoretical heave and pitch responses of the sprung mass of a vehicle traveling over a harmonic wave are obtained. The vehicle is represented as a four-dimensional lumped-parameter system and is subjected to a harmonic wave input of sufficient wavelength to allow continuous tire patch contact, but short enough to induce pitch motion. A 1/8-scale model of some general vehicle is tested to determine its mass, inertia, damping, and spring parameters. The model is run on a harmonic track (no roll motion imparted), its heave and pitch accelerations of the sprung mass center of gravity are measured, and a correlation is made with the theoretical results.
AD-724704

72—727

DYNAMIC ANALYSIS OF AUTOMOTIVE STRUCTURAL SYSTEMS
Selna, L. and Salinas, D. (School Engr. Appl. Sci., Univ. Calif. Los Angeles, Calif.)
SAE Paper No. 700844 (Oct. 5-9, 1970)
11 refs

Key Words: automobiles, collision research, dynamic response

A mathematical model being developed for the study of vehicle dynamic behavior of crash environments is presented. Such a model will allow the simulation of many vehicle structure-crash combinations at low cost. Ultimately the

model is to be used as a design tool for determining structural configurations which optimize passenger safety. The initial phase of the work is described, and a simulation of a frontal vehicle crash is presented using the model at its present level of development.

72—728

A STUDY ON AUTOMOBILE CRASHWORTHINESS
Tani, M. and Emori, R.I. (Mitsubishi Heavy Indus., Ltd.)
SAE Paper No. 700175 (Jan. 12-16, 1970)
5 refs

Key Words: automobiles, collision research, mathematical models

Crash mechanisms of automobiles are simulated by a nonlinear, three degree-of-freedom system. Crashworthiness of vehicle structures is obtained analytically and experimentally, and is represented by nonlinear springs. Analytical results are compared with full-size experiments of barrier and rear-end collisions. It is shown that the automobile crash mechanisms may be explained by a simple model, and that a theoretical computation may be feasible to obtain the crashworthiness of vehicle structures.

ROTORS

(Also see No. 839)

72—729

HYDROELASTIC VIBRATIONS OF A UNIFORMLY ROTATING INFINITELY LONG CIRCULAR CYLINDRICAL CONTAINER
Bauer, H.F.
Acta Mechanica 12 (3-4), 307-326 (1971)
3 refs

Key Words: fluid-filled containers, liquid, sloshing

The behavior of an incompressible and nonviscous liquid with a free surface in a uniformly fast rotating infinitely long elastic circular cylinder is discussed. The natural frequencies of the liquid in a rigid container, in addition to the response of the liquid to forced rigid and elastic container wall excitations are presented. The determination of the hydroelastic spin-slosh problem is presented, since the elasticity of the spinning container wall may considerably influence the magnitude of the coupled frequencies of the liquid-structure system.

72—730

A TWO-DIMENSIONAL THEORY FOR ROTOR BLADE FLUTTER IN FORWARD FLIGHT
Shipman, K.W. and Wood, E.R. (Rochester Appl. Sci. Assoc., Inc., Rochester, N.Y.)
J. Aircraft 8 (12), 1008-1015 (Dec. 1971)
9 refs

Key Words: flutter, rotary wings, two-dimensional problems

A theoretical method for determining rotor blade flutter in forward flight is presented. The unsteady aerodynamic contribution of the wake below the rotor is taken into account. It is assumed at the onset of flutter that oscillations begin to build up prior to the blade reaching a critical azimuth position, then decay as the blade moves beyond this point. A wake model is based on this and the resulting lift deficiency function is compared with that of Loewy and Theodorsen. The work is consistent with earlier flutter theory. The theory is applied to bending-torsion flutter for the tip segment of a rotor blade and the influence of advance ratio on flutter speed is found to be essentially constant.

72—731

THE EFFECTS OF NONLINEAR ASYMMETRIC SUPPORTS ON TURBINE ENGINE ROTOR STABILITY
Williams, R., Jr. and Trent, R. (Allison Div., Gen. Motors Corp.)
SAE Paper No. 700320 (Apr. 20-23, 1970)
3 refs

Key Words: balancing, rotors, turbine components, whirling

A rotor-shaft system supported at one end by a spline coupling, and at the other end by a flexible bearing support having asymmetric and nonlinear characteristics is analyzed. The effects of nonlinearity and asymmetry in the flexible support, on the response to excitation from sliding friction in the spline coupling and rotor unbalance are investigated. The spline friction is represented as coulomb friction. As a result of the sliding friction excitation, a bounded nonsynchronous whirl is shown to occur at rotational speeds above the undamped natural frequency of the system.

SELF-EXCITED

(Also see Nos. 630, 635, 640, 645, 671, 730)

72—732

EFFECT OF FIN SLOTS ON THE STATIC AND DYNAMIC STABILITY CHARACTERISTICS OF FINNED BODIES
Clare, T.A. and Daniels, P. (Warfare Analysis Dept., Naval Weapons Lab., Dahlgren, Va.)
31 pp (June 1971)

Key Words: dynamic stability

Static and dynamic stability characteristics of a cruciform, slotted fin configuration are presented. Aerodynamic coefficients are extracted from single degree-of-freedom, free oscillation wind tunnel tests employing nonlinear least squares procedures. The linear and nonlinear variations with angle of attack of the restoring and damping moment coefficients are presented for various fin slot sizes at subsonic speeds. Results indicate that, as slot size increases, the nonlinear contributions decrease in magnitude to a greater extent than the linear terms. Based on the signs of the various moment contributions, it was found that while stability is reduced at small angles of attack because of increased slot size, greater stability is affected at moderate angles of attack.
AD-728016

SHIP

(Also see No. 620)

72—733

INSULATION IN TRANSPORT
Castle, P.D. (Turner and Newall Ltd.)
Engr. Matl. Design 14(11), 1108-1109 (Dec. 1971)

Key Words: shock isolation, transportation systems, noise reduction, vibration control

The role of insulation in protecting people, cargo and equipment from fire, temperature extremes, impact, vibration, and noise is investigated. Desirable characteristics of insulating material are discussed.

72—734

MOTION OF FREELY SUSPENDED LOADS DUE TO HORIZONTAL SHIP MOTION IN RANDOM HEAD SEAS
Zwibel, H.S. (Naval Civil Engr. Lab., Port Hueneme, Calif.)
29 pp (Oct. 1971)

Key Words: cables, ships

A theory is developed for the swinging motion induced in a wire suspended load caused by the horizontal motion of a ship. An explicit formula is obtained for the significant amplitude of horizontal load motion when the ship is exposed to random head seas. Numerical results are presented for two typical cargo ships in a sea state three. It is found that very large motions are suffered by the load. For critical line lengths, resonance effects magnify the ship motion by several orders of magnitude. The results can be used to assist in the development of on-loading and off-loading devices for cargo vessels in open beach operations.
AD-732368

SPACECRAFT

(Also see Nos. 567, 624, 644)

72—735

MODAL ANALYSIS OF THE MATED SPACE SHUTTLE CONFIGURATION
Gieseke, R.K. (Convair Aerosp. Div., Gen. Dynam. San Diego, Calif.)
Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 15 pp, 1 ref

Key Words: computer programs, finite element techniques, modal analysis, NASTRAN, space shuttles

The development of analytical dynamic models for the space shuttle system is traced from simplified early versions through current models of complex representation. The sequence of models also displays changes in design that have occurred during configuration definition and development activities. Alterations to the analytical models for accuracy of representation and improved graphical display are explained. A discussion is included that examines the program characteristics of NASTRAN, particularly as it operates within the environment of the computer monitor system and influences the analysis procedure.

72—736

ACOUSTIC ANALYSIS OF SOLID ROCKET MOTOR CAVITIES BY A FINITE ELEMENT METHOD

Herting, D.N.; Joseph, J.A.; Kuusinen, L.R.; and MacNeal, R.H. (MacNeal-Schwendler Corp.)

Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 39 pp. 10 refs

Key Words: acoustic response, cavities, finite element technique

An approach to the solution of acoustic modes in a cavity containing both axisymmetric regions and evenly spaced radial slots is described. A finite element approach is used with degrees of freedom taken as the harmonic coefficients in a Fourier expansion of the pressure. If the assumptions are made that the radial slots are evenly spaced around the circumference and that the circumferential pressure gradient within each slot is negligible, the equations for the harmonic coefficient become uncoupled. Formulas are derived by which the finite element stiffness and mass matrixes may be computed. In addition, special terms are derived to account for rapid expansion of the flow in the opening between the slots and the circular cavity. Results are given for three operational solid rocket motors having 4, 6, and 12 radial slots respectively. Comparisons with other analytical results and with experimental results are given where these data are available.

72—737

NORMAL MODE ANALYSIS OF THE RADIO ASTRONOMY EXPLORER (RAE) BOOMS AND SPACECRAFT

Jabbour, K.N. (NASA-Goddard Space Flight Ctr.)

Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 12 pp, 7 refs

Key Words: antennas, booms, finite element technique, NASTRAN, normal modes, spacecraft

The problem of determining the normal modes of RAE booms and spacecraft for in-flight configuration is analyzed. The solution is based on the use of a finite element model of the booms and spacecraft along with NASTRAN's normal mode analysis. The inverse power method of eigenvalue extraction is utilized. The results are presented as a summary of real eigenvalues and plots of the six rigid body mode shapes, the eight first mode shapes, and the eight second mode shapes.

72—738

APPLICABILITY OF STATISTICAL ENERGY CONCEPTS TO THE MM '69 SPACECRAFT

Mansour, M.N. (Calif. Inst. Tech.)

SAE Paper 700181 (Jan. 12-16, 1970) 5 refs

Key Words: spacecraft, statistical energy methods, testing techniques, vibration tests

Analytical methods of estimating damping and coupling factors, necessary to analyze structural vibration using statistical energy concepts, become very difficult for complicated spacecraft type structures. The applicability of statistical energy concepts to such a structure is experimentally investigated employing system level random vibration tests on the Mariner Mars 1969 Dynamic Test Model.

72—739

COMPLEX EIGENVALUE SOLUTION TO A SPINNING SKYLAB PROBLEM

Patel, J.S. and Seltzer, S.M. (Teledyne-Brown Engr. Co., Inc., Huntsville, Ala.)

Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 10 pp, 1 ref

Key Words: eigenvalue problems, finite element technique, NASTRAN, spacecraft

A study to determine the possibility of spinning the Skylab (the U.S.'s first manned orbiting space station) is presented. The purpose of the spin is to provide an artificial gravity environment to assess and compare the physiological and mental ramifications of prolonged zero gravity and artificial gravity environments. The results will be appropriate for analysis of future spacecraft, particularly those that are combined of several connected bodies with attached flexible appendages (such as Skylab).

72—740

APPLICATION OF NASTRAN TO A SPACE SHUTTLE DYNAMICS MODEL

Thornton, E.A. (Old Dominion Univ.)

Presented at Colloquium NASTRAN: User's Experiences, NASA-Langley Res. Ctr., Hampton, Va. (Sept. 13-15, 1971)
NASA TM X-2378, 17 pp, 3 refs

Key Words: finite element technique, NASTRAN, spacecraft

A NASTRAN analysis of the normal modes of a 1/15-scale space shuttle dynamics model is described. Fuselage and wing components are analyzed in a free-free condition and assembled

to give the complete model. The finite element idealization employs bar elements, concentrated masses, general elements and modeled rigid connections using multipoint equations of constraint. A Guyan reduction is used, and the eigenvalue problem for the complete model is solved using the Givens method.

72—741

USE OF CENTAUR SPACECRAFT FLIGHT DATA IN THE SYNTHESIS OF FORCING FUNCTIONS AT CENTAUR MAIN ENGINE CUTOFF DURING BOOST OF MARINER MARS 1969, OAO-II, AND ATS SPACECRAFT -- PART I: ANALYSIS AND EVALUATION
Trubert, M.R.; Chisholm, J.R.; and Gayman, W.H. (Jet Propulsion Lab., Pasedena, Calif.)
Tech. Memo. 33-487 (June 21, 1971)

Key Words: forcing phenomena, spacecraft, synthesis

Acceleration flight data of Mariner Mars 1969, OAO-II, and ATS spacecraft in the boost phase are used to determine the disturbing forcing function of the Centaur engines at the main engine cutoff event. An inverse solution using the concept of Fourier transform and transfer function is presented. Mathematical dynamic models of the spacecraft and the Centaur launch vehicle are derived and Fourier transforms and time histories of the disturbing forcing function are determined. Analysis to determine the response and reaction forces and moments of another spacecraft using the same Centaur vehicle is derived.

72—742

USE OF CENTAUR SPACECRAFT FLIGHT DATA IN THE SYNTHESIS OF FORCING FUNCTIONS AT CENTAUR MAIN ENGINE CUTOFF DURING BOOST OF MARINER MARS 1969, OAO-II, and ATS SPACECRAFT -- PART II: COMPUTER PLOTS
Trubert, M.R.; Chisholm, J.R.; and Gayman, W.H. (Jet Propulsion Lab., Pasedena, Calif.)
Tech. Memo. 33-487 (June 21, 1971)

Key Words: forcing phenomena, spacecraft, synthesis

Acceleration flight data for five Centaur main engine cutoff events and selected gimbal axis forcing functions are presented. The Centaur gimbal axis forcing functions for the two Mariner Mars 1969 flights derived from the corresponding field joint acceleration flight data, are presented. Selected components of the forcing functions, derived from acceleration flight data for the OAO-II and ATS spacecraft, are also given.

72—743

USE OF DERIVED FORCING FUNCTIONS AT CENTAUR MAIN ENGINE CUTOFF IN PREDICTING TRANSIENT LOADS ON MARINER MARS '71 AND VIKING SPACECRAFT
Trubert, M.R.; Chisholm, J.R.; and Gayman, W.H. (Jet Propulsion Lab., Pasedena, Calif.)
Tech. Memo. 33-486 (June 28, 1971)

Key Words: forcing phenomena, spacecraft

The disturbing forcing functions of the Centaur engines at main engine cutoff derived from acceleration flight data of the Mariner Mars 1969 spacecraft are used to predict acceleration and reaction forces and moments near the base of Mariner Mars 1971 and Viking spacecraft. Mathematical dynamic models of the Mariner Mars 1971 and Viking spacecraft and the Centaur launch vehicle modified for the Viking model are presented. Discussions concerning the method and the accuracy of the results are given.

72—744

THE DYNAMICS OF SOUNDING ROCKETS AT BURNOUT
Womack, W.C.
114 pp (1971)

Key Words: lateral response, rockets

An integrated approach to the investigation of the dynamic characteristics of elastic rocket vehicles is presented. The equation of motion is developed in such a manner that external forces and moments can be determined by acceptable methods and combined with other motions into the equations. A sample problem using an actual flight system is solved. The physical characteristics and parameters are modeled on an analog computer. The analysis by this method simulates actual flight data with excellent results. The extra-atmospheric coning motion is shown to be caused by the coupling of the lateral vibrational motion with the rolling motion.
UM 72-3454

STRUCTURAL

(Also see Nos. 542, 559, 560, 563, 566, 594, 596, 597, 693)

72—745

TRANSIENT DYNAMIC RESPONSE OF SOME NONLINEAR STRUCTURAL SYSTEMS
Ayre, R.S. and Mays, J.R. (Dept. Civil Envir. Engr., Univ. Colo., Boulder, Colo.)
Computers and Struc. 1(4), 511-534 (Dec. 1971) 59 refs

Key Words: nonlinear systems, transient response

Examples of the transient dynamic response of various single degree-of-freedom and many degree-of-freedom simplified nonlinear structural systems are shown through a presentation of general equations of motion, nonlinear damping and restoring force functions, and the use of nonlinear-system response spectra. A few examples of response spectra are shown for widely different families of nonlinear systems having widely varying parameters.

72—746

USE OF AN AERODYNAMIC OBSTRUCTION TO SHIELD A BLAST DOOR-RESULTS OF AN EXPERIMENTAL MODEL TEST
Ferritto, J.M. (Naval Civil Engr. Lab., Port Hueneme, Calif.)
34 pp (Oct. 1971)

Key Words: blast resistant design, entrances, openings, protective shelters

The protection afforded by an obstruction is evaluated and the relative width of obstruction required to protect a given width of entrance is determined. Similitude relationships are developed. A series of tests conducted in which a protected and an unprotected model structure are subjected to blast waves from explosive charges is reported. A 45 deg triangular prismatic obstruction is used to shield the protected structure. Fifteen variations of width and position of obstruction are evaluated. Results show that at the 100 psi overpressure level, an obstruction 1 door height high and 2 door-widths wide placed from 1 to 2 door heights away from a structure can reduce the peak reflected pressure by 50 percent.
AD-732362

72—747

DESIGN PROCEDURES FOR SHELTER ENTRANCE STRUCTURES TO RESIST BLAST OVERPRESSURE AND RADIATION EFFECTS
Ferritto, J.M. (Naval Civil Engr. Lab., Port Hueneme, Calif.)
161 pp (Sept. 1971)

Key Words: blast resistant design, entrances, openings, protective shelters

Engineering methods to design hardened entrance structures of nuclear warfare shelters to resist the effects of both blast overpressure and radiation are presented. The design overpressure level can be determined from probability data, and the entrance can be sized to accommodate the required traffic flow. Methods are presented to calculate the reflected pressure on the entrance for various entrance configurations and procedures are given to design the door structurally to resist the applied loads. Radiation attenuation methods are presented to evaluate the requirement for additional shielding. Various materials are considered to provide more effective economical shields. Summaries of door tests performed in the Operation PLUMBBOB test series are given.
AD-732359

72—748

COST-OPTIMIZATION STUDY OF SHELTER ENTRANCE STRUCTURES TO RESIST BLAST OVERPRESSURE AND RADIATION EFFECTS
Ferritto, J.M. (Naval Civil Engr. Lab., Port Hueneme, Calif.)
36 pp (Sept. 1971)

Key Words: blast resistant design, doors, entrances, protective shelters

A computer program to study 96 door-entrance combinations for various door sizes and radiation-overpressure levels is available. The relative costs of various doors, entrances, and door-entrance combinations are evaluated. Steel tension membrane doors and reinforced concrete slab doors are the most economical. Aerodynamic triangular obstructions placed in front of a door, sloped doors, and unprotected doors are the most cost-effective.
AD-732360

72—749

DISCRETE TIME SERIES SYNTHESIS OF RANDOMLY EXCITED STRUCTURAL SYSTEM RESPONSE

Gersch, W. and Luo, S. (Univ. Hawaii, Information Sci. Program, Honolulu, Hawaii)

J. Acoust. Soc. Am. 51(1), 402-408 (Jan. 1972) 15 refs

Key Words: computer programs, dynamic systems, random excitation

A set of digital computer techniques for the generation of second-order stationary time series for the experimental and numerical study of certain problems is described. The problems are restricted to those involving the response of structural systems under random excitation. A discrete time system whose output covariance is identically that of the regularly sampled observations of a white noise excited continuous time dynamical system is synthesized. It is assumed that the dynamical system is an n degree-of-freedom system represented by a set of ordinary differential equations. Examples of the synthesis of 2 and 10 degree-of-freedom systems in addition to the synthesis of a rigid body transfer function approximation to a rocket are provided.

72—750

STRUCTURAL STABILITY IN EARTHQUAKE ENGINEERING

Gurpinar, A.

99 pp (1971)

Key Words: dynamic stability, seismic design

Practical solutions to the stability problem in earthquake engineering are sought. A column supporting a concentrated mass at the top is treated as a single degree-of-freedom system. The system is assumed to be linearly elastic with viscous damping. It is subjected to both horizontal and vertical random acceleration at the base, which are taken to be a band limited white noise simulating earthquake motions. The probability of instability of the system is determined. Two methods of solution are presented: one in which the problem is treated as a crossing problem; and another which solves the nonhomogeneous Mathieu equation. Probabilities of instability of 25 columns selected from the AISC Steel Construction Manual are computed by using the first method. Five of these are also computed by the second method. Comparison of the two methods is reasonable. The probabilities of instability for all columns studied are found to be significant. The coupling effect can increase the probability of instability of certain columns by as much as 10,000 times. On the basis of this study, design curves can be prepared for all column sizes to enable design engineers to choose safer columns in practice.
UM 72-4006

72—751

CONVERGENT APPROXIMATIONS OF PROBLEMS OF IMPULSIVELY LOADED STRUCTURES

Ho, H.S. (Dept. Civil Engr., Univ. S. Calif. Los Angeles, Calif.)

J. Appl. Mech., Trans. ASME 38(4), 852-860 (Dec. 1971) 16 refs

Key Words: beams, shock excitation

It is found that a dynamically admissible solution for a dynamically loaded system mode of stable materials is one that satisfied all but the initial conditions, and is a definitely convergent solution in time, with geometry changes and discontinuities taken into account. A new simpler definition for weak and strong discontinuities is proposed. Solutions are presented using simple mode approximations or the more general time-dependent changing mode approximations. For rigid, perfectly plastic beams under impulsive loadings, the latter method gives better results.

72—752

INTERACTION BETWEEN EQUIPMENT STRUCTURES AND UNDERWATER SHOCK WAVES

Scavuzzo, R.J. (Dept. Mech. Engr. Toledo, Univ., Ohio)

76 pp (June 1971)

Key Words: submerged structures, underwater explosions

The response of hull-mounted submarine equipment structures can be idealized as an N-mass system and the hull as a rigid circular cylinder. Motion of the cylinder is determined by reflection of a one-dimensional pressure wave from the cylinder. Cavitation at the hull-water interface is included in the analytical model. Results of this study are compared to those obtained using a flat plate representation of the hull. Because of the hull curvature in this improved model, the risetime of the equipment is much less than in the previous model. As a result, agreement with trends observed in the experimental data are improved.
AD-731717

72—753

DEVELOPMENT OF A STOCHASTIC WAVE FORCE FUNCTION ON OCEAN-STRUCTURES
Schueller, G.I. (Dept. Civil, Mech. and Envir. Engr., George Washington Univ., Washington, D.C.)
Computers and Struc. 1(4), 639-649 (Dec. 1971) 11 refs

Key Words: fluid excitation, offshore structures

Since a deterministic approach to wave force prediction appears to be impossible, a probabilistic approach is developed. The method applied utilized a multiple linear regression analysis to develop a relationship between wave parameters which are relatively easy to observe and the parameters used in the Morison force equation. These include the velocity and acceleration of water particles and the drag and mass coefficients and are considered to be random variables. The assumption of their lognormal distribution is reasonably well verified. Using Monte Carlo simulation the author uses these regression relations to generate the frequency function of the wave forces. The wave force function can best be described as a stationary periodic process and can be used as an input function for a probabilistic dynamic analysis of offshore structures.

72—754

LIFT OR ACROSS-WIND RESPONSE TO TAPERED STACKS
Vickery, B.J. and Clark, A.W.
J. Struc. Div., Proc. ASCE 98 (ST1), 1-20 (Jan. 1972) 8 refs

Key Words: aerodynamic excitation, chimneys, vortex shedding

The structure of the shedding forces from a slender tapered structure is studied in considerable detail in both smooth uniform flow and turbulent shear flow. A simplified description of the forces in shear flow is developed and successfully employed to predict the response of an aeroelastic model. A significant finding is that the maximum response in the fundamental mode occurs when the shedding frequency at about one-third of the stack height is equal to the natural frequency. An equation is developed to predict the behavior of full-scale structures. The significance of loads resulting from vortex shedding from tapered structures is examined. For typical concrete structures it it deduced that drag loads are likely to be dominant with regard to stresses over the lower two-thirds of the structures while vortex excitation of the second mode is likely to be the dominant consideration for the upper one-third or thereabouts.

72—755

CREEP FAILURE OF RANDOMLY EXCITED STRUCTURES
Yang, J.N.
Jet Propulsion Lab. Space Program Summary 37-66, III, 120-128, (Dec. 31, 1970)

Key Words: random excitation, structural response

A method is developed for the prediction of creep failure of structures under random excitations. The fracture mechanics concept and the cumulative flaw growth hypothesis are employed to obtain the statistical characteristics of the relative flaw growth of structures under random loadings. The probability of creep failure is evaluated using the principle of maximum entropy. Two numerical examples are used to illustrate the general results.

TRANSMISSIONS

(Also see No. 576)

TURBOMACHINERY

(Also see Nos. 543, 636, 638)

72—756

DYNAMIC BEHAVIOR AND CONTROL OF SINGLE-SHAFT CLOSED-CYCLE GAS TURBINES
Bammert, K. and Krey, G. (Inst. Turbomach., Gasdyn. and Nuclear Engr., Univ. Hannover, Hannover, Germany)
J. Engr. Power, Trans. ASME 93(4), 447-455 (Oct. 1971) 8 refs

Key Words: dynamic response, turbine components

The dynamic behavior of nuclear closed-cycle gas turbines is determined by the gas volumes in the ducts and apparatuses, the relatively great thermal inertias of the reactor and the heat exchangers, and by the inertia moment of the rotor. The basic equations, describing the dynamics, and a method for solving them by means of a digital computer are given. The sufficiency of the theory is demonstrated. The known actions of power control (changing the gas inventory and opening a bypass) are investigated with regard to dynamics. A special power-speed controller is explained. The results of a calculation are discussed which show the control action of a closed-cycle gas turbine controlled by an isostatic speed controller.

72—757

EXPERIMENTAL INVESTIGATION OF METHODS FOR IMPROVING THE DYNAMIC RESPONSE OF A TWIN-SPOOL TURBOJET ENGINE

Fawke, A.J. and Saravanamuttoo, H.I.H. (Engr. Res. Station, Gas Council, Newcastle, England)

J. Engr. Power, Trans. ASME 93 (3), 418-424 (Oct. 1971) 3 refs

Key Words: dynamic response, engines, experimental results, turbine components

Experimental tests carried out on a twin-spool turbojet to confirm earlier simulator predictions of methods of improving the dynamic response is reported. The engine is controlled by a digital computer. Dynamic response can be improved by trading HP surge margin for LP surge margin by suitable variation of the nozzle area. Operating trajectories are obtained on both compressor characteristics during both accelerations and decelerations. Excellent agreement with simulator results is obtained.

72—758

A NOTE ON MULTIPLE PURE TONE NOISE

Kurosaka, M. (Corp. R & D Ctr., Gen. Elec. Co., Schenectady, N.Y.)

J. Sound and Vib. 19 (4), 453-462 (Dec. 22, 1971) 10 refs

Key Words: aircraft noise, rotor blades (turbomachinery)

A theoretical investigation of multiple pure tone noise is presented. An analysis based on a two-dimensional inviscid flow model is developed to predict the generation and subsequent evolution of multiple pure tone noise from prescribed blade-to-blade nonuniformities in the rotor geometry. The results show that even small nonuniformities within manufacturing tolerances can be a significant source of multiple pure tone noise. Among the nonuniformities investigated, errors in blade spacing are less significant multiple pure tone noise sources than errors in blade stagger or blade contours.

72—759

NOISE CONSIDERATIONS IN THE DESIGN OF ADVANCED SUBSONIC TRANSPORT TURBOFAN ENGINES

Neitzel, R.E. and Benzakein, M.J. (Gen. Elec. Co.)

SAE Paper No. 700807 (Oct. 5-9, 1970) 1 ref

Key Words: aircraft, noise reduction

The problems and choices in the design of an advanced subsonic transport turbofan for reduced noise and improved aircraft performance are examined. The effects of bypass ratio, fan pressure ratio, and fan tip speed on jet noise, fan noise, and acoustic treatment suppression are described. The results do not indicate a clear optimum bypass ratio considering the effects upon installed engine performance and weight in addition to acoustic performance. Low-fan tip speed designs with the associated high aerodynamic loading are compared to high-tip speed low loading designs. Other factors affecting noise such as the installation and other noise sources are discussed. The long duct installation is indicated to have potential advantages over the short duct separate flow installations. The problem of assuring that growth models of an engine also have low noise is discussed.

72—760

SHOCK AND VIBRATION TESTS OF A SNAP-8 TURBOALTERNATOR

Stromquist, A.J.; Hibben, L.; and Foley, R.S. (Lewis Res. Ctr., NASA, Cleveland, Ohio)

NASA TM X-67851, 27 pp (May 1971)

Key Words: missile launchers, shock tests, vibration tests

A turboalternator for the SNAP-8 space power system is subjected to the expected vehicle launch vibration and shock loading in accordance with the SNAP-8 environmental specification. Subsequent disassembly and detailed inspection reveal some internal damage out the unit is judged to be operational.
NSA-1626

72—761

PREDICTION OF SILENCER PERFORMANCE USING TRANSMISSION LINE THEORY

Wells, R.J. and Tatge, R.B. (R & D Ctr., Gen. Elec. Co., Schenectady, N.Y.)

J. Engr. Power, Trans. ASME 93 (4), 404-410 (Oct. 1971) 13 refs

Key Words: noise reduction, turbine components

The size and cost of gas turbine exhaust silencers are largely determined by low frequency requirements. The silencer cross-dimensions are small compared to the wavelength; it can therefore be considered to be one-dimensional. Equations can be written to predict the acoustical performance which are analogous to those governing electrical transmission lines.

72—762

DEVELOPMENT AND TESTING OF TECHNIQUES FOR OSCILLATING PRESSURE MEASUREMENTS ESPECIALLY SUITABLE FOR EXPERIMENTAL WORK IN TURBOMACHINERY
Weyer, H. and School, R. (DFVLR-Institut für Luftstrahlantriebe, Porz-Wahn, Germany)
J. Basic Engr., Trans. ASME 93 (4), 603-609 (Dec. 1371) 7 refs

Key Words: measurement techniques, oscillations, testing techniques, turbomachinery

The development of techniques which permit the measurement of well-defined average values of oscillating pressures in the region of turbomachine rotors is described. Two of them are able to measure the true time-averaged pressures with an accuracy better than 0.5 percent of the acting pressure amplitude. The third is based on an evaluation method by means of which the average pressures indicated by special pneumatic measuring systems can be correlated to the true time-weighted values. Experimental and computed results show good agreement.

USEFUL APPLICATION

(Also see Nos. 604, 616, 623, 641, 643)

72—763

UTILIZATION OF VIBRATIONAL COMPACTION FOR NUCLEAR FUEL
Ferrari, S.; Giaquinto, L.; and Petrucciani, N. (Comitato Nazionale per l'Energia Nucleare, Rome, Italy)
Presented at Italian-Polish Meeting, Warsaw, Poland, (May 26-June 6, 1970); 29 pp (Oct. 2, 1971)

Key Words: nuclear fuel components, vibratory compacting

The vibrational compaction technique in the field of nuclear energy represents an alternative to the most traditional and characteristic processes of powder metallurgy, such as pelleting and sintering. In this technique, great importance must be attributed to the preparation of dense material. The application of the method to some types of dense oxides is discussed. Also, an original process for the preparation of UO2 is described.
N71-37043

72—764

THE EFFECT OF ULTRASONIC VIBRATIONS ON THE STEADY STATE HEAT TRANSFER OF A BODY IN LIQUID HELIUM II
McKinnon, M.A.
92 pp (1971)

Key Words: heat transfer, ultrasonic vibration

An experimental investigation conducted to determine the effects of ultrasonic sound on the steady nonfilm boiling heat transfer from a horizontal cylinder immersed in a liquid helium II bath at 2.0 K is described. The sound field is generated by a cylindrical, piezoelectric transducer at a frequency of 44 kHz. The heat flux was varied from 0.05 to 0.3 w/cc. A decrease in heat transfer is observed for sound intensities greater than a critical sound intensity. The maximum observed decrease in heat flux is 30 percent. The correlation of the results with acoustic mismatch theory, cavitation, and thermoacoustic streaming is discussed. The decrease in heat transfer because of a sound field cannot be explained by altering the acoustic mismatch theory, but the results can be explained by the superpostion of acoustically induced cavitation and thermoacoustic streaming.
UM 72-4726

72—765

THE EFFECTS OF MODE OF VIBRATION AND BLADE ANGLE ON THE PERFORMANCE OF A SIMPLE VIBRATORY TILLAGE TOOL
Smith, J.L.
169 pp (1971)

Key Words: agricultural machinery, vibrators (machinery)

The average horizontal force acting on a tillage tool can be reduced by vibrating that portion of the tool which cuts or manipulates the soil. Equations are developed to compare the horizontal force and power requirements of a vibrating and nonvibrating tillage tool. It is proved that the power required for a tillage tool cannot be reduced by vibration, and that the power required approaches infinity as the contact ratio approaches zero. The equations are modified to include a description of the experimentally observed increase in the length of soil-tool contact and the transition in the mode of soil failure from shear to flow with vibration. The predicted results are in agreement with the experimental results.
UM 72-390

AUTHOR INDEX

BOOKS

DYNAMICS OF STRUCTURED SOLIDS
The American Society of Mechanical Engineers
New York, N.Y. (1968)

This book consists of a series of papers presented in a symposium on the Dynamics of Structured Solids sponsored by the Applied Mechanics Division of ASME during the 1968 Winter Annual Meeting of the ASME. There is much activity today in the field of composite materials. It is indeed refreshing to see that the papers included in this book reflect a broad range of research topics in this area, from the application of lattice and continuum theories in the vibration of crystalline elastic solids, to geophysical applications. In the latter case, the earth's vibrations are studied and the earth is considered as a radially stratified sphere. The six papers contained in this volume are briefly discussed.

"Lattice and Continuum Theories of Simple Modes of Vibration in Cubic Crystal Plates and Bars", by R. D. Mindlin, bridges the gap between discrete and continuum models in the study of vibration modes of crystalline elastic solids. Analytical solutions in closed form are obtained by using the Gazis-Herman-Wallis finite difference equations for a simple cubic crystal lattice for some vibration modes in plates and bars. The simple character of the solution facilitates the study of frequencies and mode shapes as the dimensions of the bodies and the wave lengths increase from atomic to macroscopic sizes, in which case classical continuum theory is applicable.

"Surface Deformation and Surface Waves in Crystal Lattices", by D. C. Gazis, discusses the surface deformation of a crystal lattice near a boundary plane, the surface modes and pseudo-surface modes of vibration in cubic crystal lattices and estimates of mean square velocities of surface atoms. The latter are of interest in Mossbauer effect experiments. The lattice models used incorporate the effect of central force as well as "angular stiffness" interactions between a typical particle and its two nearest neighbors. These models match the results predicted by continuum theory when the wavelengths of deformation are long in comparison with the interatomic distance.

"Wave Motion in Solids with Lamellar Structuring", by J. D. Achenbach and G. Herrmann, analyzes the time-harmonic vibrations of a laminated medium by employing the equations of the theory of elasticity for each layer as well as by the use of an approximate continuum theory for the layered medium. The frequency equations, which exhibit marked dispersive behavior, are determined by means of exact in addition to approximate theories. A comparison between exact and approximate frequency vs wavenumber curves shows good agreement.

This paper is a continuation of the work in which the authors are engaged, in collaboration with C. T. Sun, and is referenced in the present paper. The reader is advised to consult these references before attempting to understand the present paper.

"Dynamic Behavior of Textile Fibers and Assemblies", by C. F. Zorowski and T. Murayama, gives the results of a theoretical and experimental investigation of the dynamic response of twisted yarns composed of continuous viscoelastic filaments subjected to high-frequency periodic strain disturbances. The objective of this study is to determine the effect of geometric twist in the yarns on the effective dynamic modulus of the fiber assemblies. The comparison of predicted vs measured results indicates that the proposed model is a realistic one, and provides insight into the dynamic response of viscoelastic filaments and yarn assemblies subjected to high-frequency strain disturbances when the filaments are undergoing nonlinear behavior.

"Analysis of Vibratory Energy Distribution in Compsite Structures", by E. E. Ungar and J. E. Manning, summarizes the "statistical energy" approach for analyzing steady state

vibration in composite structures in terms of relatively simple energy balance. The foundations of the method are indicated, and the methods for the determination of the necessary parameters are discussed. Results obtained by this approach are compared with experimental data.

"Elastic-Gravitational Vibrations of a Radially Stratified Sphere", by F. Gilbert and G. Backus, finds the normal modes of vibration of a radially stratified sphere by using a separation of variables approach in the transformed equations of dynamic elasticity. The problem is thus reduced to a set of ordinary differential equations in which the state vector must remain continuous across each interface. The solution of the problem is then accomplished by the transfer matrix approach suggested by Thomson and Haskell and referenced in the present paper.

The reviewer recommends this book to any reader interested in the dynamics of a medium that exhibits some sort of structure. He will find up-to-date predictions of dynamic behavior of structured solids based on lattice, continuum and stochastic models. However, this is not an introductory text. The papers in this symposium volume are highly specialized.

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PRINCIPLES AND TECHNIQUES OF SHOCK DATA ANALYSIS
Ronald D. Kelly and George Richman
The Shock and Vibration Monograph Series, SVIC
Naval Res. Lab.
Washington, D.C. (1971)

The book is concerned with analyses of mechanical shock data. The first three chapters are devoted to introduction, a review of mathematical procedures (differential equations, Fourier and Laplace transforms), and a review of methods for calculating responses of linear systems. Chapter 4 is devoted to a discussion of the Fourier spectrum and the shock spectrum. Analog equipment techniques used to evaluate these quantities are presented in Chapter 5, and digital methods of treating shock data are discussed in Chapter 6. Sources of error in each method are also discussed in the respective chapters. Nonspectral techniques used in processing some types of shock data are presented in the last chapter. In addition, topics under the headings of "Analysis of Random Transients" and "Extensions of the Basic Shock Spectrum Concept" are also included in this chapter.

The book provides an excellent survey of the methods used in the reduction of transient vibration input to mechanical systems; however, because of the many topics covered, some are treated in a brief manner. Usually one or two of the most significant papers or books on each topic are referenced. Therefore, the bibliography cannot be considered complete, and additional references would have been useful to the reader in some areas.

The reviewer noted one shortcoming in the book with respect to shock spectrum analyses. The significance of dynamic-interaction effects between an equipment structure and its foundation is not mentioned. In high impact shock, such as that from underwater shock, this "spectrum-dip" effect can alter peak accelerations by an order of magnitude and, thus, must be considered in data reduction.

Overall, the book is very useful to those working in the field of shock and vibration and the authors are to be complimented on their contribution.

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TRANSPORT PHENOMENA FOR ENGINEERS
Louis Theodore
Intext Educational Publishers
Scranton, Pa. (1971)

This book was written with the intent to teach transport phenomena to undergraduates at their level. It is an introductory text, and it meets the author's objectives. It introduces the fundamentals of transport phenomena without being overwhelming. It is informative and explanatory without being simplistic.

Dr. Theodore begins with a very concise introduction to vector analysis, emphasizing applications of vector theory. The balance of the book treats momentum transfer, energy transfer and mass transfer, with simple examples using standard technique. This book is recommended as a text for a beginning course.

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FULL-SCALE TESTING OF NEW YORK WORLD'S FAIR STRUCTURES
(Vols. I, II and III)
C. A. Miller
National Academy of Sciences
Washington, D.C. (1969)

The objective of the reported studies was to perform load tests on full-scale structures selected from the buildings erected for the 1964-65 New York World's Fair so that actual performance of the structures up through failure could be correlated with design theories. Three structures were selected for testing: (1) Bourbon Street, a light frame open-web steel-joint and steel-pipe column structure; (2) Rathskeller, a one-story multipanel reinforced concrete waffle-slab structure; and (3) Chimes Tower, a seven-story tower with standard structural members.

Uniform floor loads and lateral loads on the frames were applied to The Bourbon Street structure. The collapse load of the structure under uniform loading was as expected with ultimate failure of both the roof and second floor occurring at the junction between the joists and columns. Results of the lateral load test indicated that the strength was higher than would be predicted by the limit analysis method. Vibration tests were also performed on the floor system. Frequencies in the range of 8 to 12 Hz were observed with damping determined in the range of 4 to 10 percent of critical.

The Rathskeller structure was subjected to a uniform load test with the loading increased up to failure. Failure of the floor slabs occurred at 2.0, 1.4, and 3.9 times the design loads respectively for test with four interior panels loaded, three edge panels loaded, and a single interior panel loaded, giving an adequate factor of safety. Ultimate strength of the slab was governed by shear at the columns rather than flexural yielding of the slabs.

The Chimes Tower structure was subjected to dynamic tests for the purpose of determining natural frequencies and mode shapes, damping characteristics, and participation of the foundation in the motion of the tower. A mechanical oscillator was used to excite the structure and structural responses were recorded through the use of accelerometers and strain gages. The results of these tests indicated that the first two translational modes of vibration of the structure were about 2.5 and 8.5 Hz with analytically determined frequencies being 14 and 10 percent higher than the experimental values. Damping of the first mode was found to be 2 to 3 percent of critical, while damping for the second mode response was found to be 5 to 6 percent of critical. Good correlation was found between measured and calculated mode shapes. The foundation response was much less than expected in view of the poor soil conditions.

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New York, N. Y.

ALGEBRAIC TRANSIENT ANALYSIS
Robert Miller
Rinehart Press
San Francisco, Calif. (1971)

This book is essentially a textbook for an undergraduate course on the mathematics to solve electrical transient problems. The text treats the problem not as a practical application of mathematics, but rather, mathematics is used as a tool. The development of this tool and its application to electric networks are the unique features of this book. This mathematical tool can also be applied to any other system. A good understanding of algebra is enough to follow the mathematics.

A brief review of the fundamental mathematics and the laws of electricity are given in the beginning of the book. The next four chapters are devoted to the transient analysis of the basic electrical components and their combinations, then, the network. The particular mathematical method used is called the "P-transform method." This method has the advantage of solving very complex problems using only algebra.

Transient responses resulting from different forms of excitation functions and initial condition are studied in the next three chapters. The final two chapters are devoted to studying frequency response plots, pole-zero plots, and the extension of the transfer function to include feedback; and to reviewing the system functions for the excitation and the response. The main thrust was aimed at the development of the system function. When an accurate description of any system has been developed and transformed into the P-domain, the problem is essentially solved. The Laplace transformation is introduced at the end of the book and suggestions for further study are made.

This book is excellent in organizing its materials and should be of interest and importance to many scientists and engineers working in the area of transient problems either in electrical systems or other fields, for instance, in the field of structural dynamics. The book can also be recommended as a text for an electronic technician who wants to understand the mathematics behind the actual electrical systems.

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PAPERS AND REPORTS

VIBRATION ISOLATION WITH NONLINEAR DAMPING
Ruzicka, J.E. and Derby, T.F.
J. Engr. Indus., Trans. ASME 93 (2), 627-635 (May 1971)

Refer to Abstract No. 71-1162

"Vibration Isolation with Nonlinear Damping" presents an analysis of a single degree-of-freedom system composed of a machine, simulated by a rigid mass, isolated from a foundation (implied to be infinitely stiff and massive) by a paralleled spring and damper. The force generated by the damper is taken to have the sign of the relative velocity across it and an amplitude proportional to an arbitrary power of its magnitude. The analysis is performed using the concept of equivalent viscous damping, i.e., in the analytical model used for calculations, nonlinear damper is replaced by a linear damper which, for the same relative velocity "across" it, dissipates the same energy per cycle of vibration. The authors first calculate the equivalent viscous damping coefficients for the nth power damper; then its equivalent viscous damping ratio (defined to be the ratio of the equivalent viscous damping coefficient to the linear viscous damping coefficient required to critically damp the system). Both of these quantities are expressed in terms of the amplitude of the relative displacement across the damper. The equivalent viscous damping ratio is then expressed in terms of the amplitude of the foundation motion for the case of foundation excitation, or in terms of the amplitude of the applied force for machine excitation.

It is shown that: (1) the equivalent viscous damping ratio is a function of frequency, and of a dimensionless damping parameter ζ_n; (2) the frequency dependence of the equivalent viscous damping ratio, and the form of the damping parameter, depend on whether the excitation is displacement, or velocity, or acceleration excitation of the foundation, or is force excitation of the machine (see Table 2 of the paper); and (3) the frequency dependencies of the equivalent viscous damping ratios for acceleration excitation of the foundation, and force excitation of the machine are the same.

This fact leads the authors to conclude that the absolute acceleration transmissibility equals the force transmissibility -- a conclusion which is correct only if the damping parameters (ζ_n) are equal for both types of excitation. It can be easily shown from the expressions for ζ_n in Table 2 of the paper that for the absolute acceleration transmissibility to equal the force transmissibility, the amplitudes $\bar{a}_0$ and P_0 of the foundation acceleration for foundation excitation of the system, and of the force applied to the mass, for force excitation of the system, must satisfy the relationship,

$$\frac{P_0^{n-1}}{K^n} = \frac{(\bar{a}_0/\omega_0^2)^{n-1}}{k}$$

where k is the isolator stiffness coefficient, and ω_0 is the undamped circular natural frequency of the system. For n=1, the case of a linear viscous damper, the condition is always satisfied; for n different from unity, this condition is satisfied if, $P_0 = m\bar{a}_0$ where m is the mass of the machine.

The effects of the type of damping (n is varied from 0.5 to 5) on absolute displacement, velocity, and acceleration transmissibility, on relative displacement transmissibility, and on displacement amplification factor are illustrated graphically. The curves presented were calculated from the usual expressions for these quantities derived from linear theory, except that the viscous damping ratio ζ in the linear equations is replaced by the equivalent viscous damping ratio $\zeta_{eq.}$, which can be calculated as a function of frequency ratio ω/ω_o and the damping parameter a_n using an expression derived in the test. For the curves presented, a_n was chosen for each n such that the resonant absolute displacement, velocity, and acceleration transmissibilities, and the resonant relative displacement amplification factor was near 5. The curves show that the frequency dependencies at high frequency ratios of the absolute displacement, velocity, and acceleration transmissibilities are different for a given n, and that the effects of changing n on the transmissibilities are different.

In calculating the values of $\zeta_{eq.}$ from Eq. 22 for the various kinds of excitation, the value of the a_n for the particular kind of excitation being considered is held constant independent of frequency, so that if one chooses, he can consider a_n to be evaluated at the circular natural frequency of the system, ω_o. If the expression in Table 2 for a_n for velocity and acceleration excitation are examined at circular frequency ω_o, it is easily shown that both are equal to the a_n given in Table 2 for displacement excitation, which can be written in the form:

$$a_n = \frac{C_n \omega_o^n a_o^n}{k a_o}$$

and has a simple physical interpretation. The numerator in the right side of this equation can be interpreted as the amplitude of the nth power damping force experienced by the damper when the mass in the system is held fixed and the foundation is displaced with an amplitude a_o at frequency ω_o; similarly the denominator can be interpreted as the force experienced by the spring under the same conditions.

For force excitation of the mass, a_n can be written:

$$a_n = C_n \omega_o^n \frac{P_o^{n-1}}{k^n} = C_n \frac{\omega_o^n}{P_o} \left(\frac{P_o}{k}\right)^n = \frac{C_n \omega_o^n x_o^n}{P_o}$$

where $x_o = P_o/k$; hence, a_n can again be interpreted as a force ratio. In this case, it is the ratio of the amplitude of the force the damper would experience if it were displaced with an amplitude equal to the amplitude of the displacement the spring in the system would experience, in the absence of the mass and damper, when acted on by the applied force, to the amplitude of the applied force.

The effects of varying the damping parameter a_n on absolute displacement transmissibility are also illustrated graphically, as a function of frequency ratio, for Coulomb, linear, quadratic (n=2) and cubic damping. Differences in the behavior of the system with linear (n=1) and nonlinear damping can be seen by comparing the four sets of curves. (It is well to note that the damping ratio ζ used as a parameter for the case of linear damping is not the damping parameter a_1, but rather $a_1/2$.) For all four kinds of damping, increasing a_n increases high-frequency displacement transmissibility, and decreases transmissibility at resonance (except for Coulomb damping when the damping parameter exceeds 0.8). For the values of damping parameter normally found in viscoelastic systems, the advantages of Coulomb damping are evident: namely, a narrow resonant amplification peak and lower transmissibility at high frequency ratios: however, these advantages may be offset by the higher resonant response for a given value of the damping parameter.

Much more discussion and many more conclusions are given in the text. The analyses and results presented graphically should be extremely valuable to the engineer wanting to predict isolator performance when nonlinear dampers are used. Estimates for certain quantities and types of excitation can be made from the curves that are given; estimates for other quantities can be made utilizing the techniques illustrated in the paper. One could wish for some changes in the text, in notation, and in the layout of the paper which would make the readers task easier; however, what one learns from reading the paper is worth the effort.

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SYNTHESIS OF LUMPED-PARAMETER VIBRATING SYSTEMS USING TRANSFER MATRIXES
Hibbert, J.H. and Porter, B.
Intl. J. Mech. Sci. 13 (1), 29-34 (Jan. 1971)

Refer to Abstract No. 71-842

In a previous paper, "Synthesis of Linear Lumped-Parameter Vibrating Systems by an Inverse Holzer Technique", (J. Mech. Engr. Sci. 12 (1), 17-19, Feb. 1970) reviewed in Vol. 3, No. 7 of the DIGEST, Porter describes how to find the mass (or mass inertia) distribution of a vibrating member of known stiffness properties such that the system possesses a prescribed frequency and mode shape. The present paper is virtually identical to the former work, only a few matrix brackets have been introduced. Perhaps next they will demonstrate how to use the Prohl or Myklestad approaches.

The problem is actually rather interesting. It is essentially one of identification of a forcing function for a member with known response. The static equivalent is to determine the distribution of loading, e.g., axial forces, on a structural member or mechanical element, with given material (although massless) and geometric properties, that correspond to a specified displacement pattern. The transfer matrix approach is appropriate for solving the problem. The work of the present paper can be easily extended to a completely general formulation that can be automated.

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OPTIMIZATION OF LINEAR, NONLINEAR AND ACTIVE MULTIDEGREE-OF-FREEDOM SHOCK ISOLATION SYSTEMS
Klein, G.H.
Univ. Calif., 271 pp (1971)

Refer to Abstract No. 71-1671

This paper is in fact the author's complete PhD thesis. In the first part of the paper the author uses simple one degree-of-freedom mass spring damper systems with either linear or hyperbolic tangent elasticity characteristics as his basic building blocks. Detailed treatment is then given to a rectangular package supported at its base by four pairs of simple spring-damper combinations to restrain vertical, horizontal and rotational motions. By intelligent use of symmetry this is reduced to a three degree-of-freedom model. Optimization objective is to determine the "best" passive system compared to the "optimal" active system. The main test criteria is to minimize the acceleration of the center of mass of the package subject to the condition that the package displacement remains in the available rattlespace.

For the active system the method chosen to effect this optimization is through a linear programming technique. To this end the author gives a clear exposition of the steps necessary and the problems associated in formulating the optimization of the mathematical model in linear programming terms. This is one of the best features of the paper. Another valuable part of the paper is the derivation of a theorem which is termed by the author as the optimum shock isolation theorem. Space does not permit a full exposition but in essence this theorem states that rotations of the critical point should not be allowed and that the elements of the isolator system should move at constant acceleration.

When analyzing the passive systems use is made of a relaxed steepest descent optimization method. By developing a "jump" algorithm the author has improved the method so that the global maxima rather than the local maxima may be found.

The main limitations to the paper are: (1) only two excitation pulses are considered, namely, a positive half-size pulse and an exponentially decaying pulse; and (2) only one form of nonlinearity is discussed. Despite these limitations the paper makes a valuable contribution to the field and is well worthy of detailed examination by those who are concerned with shock isolation.

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DYNAMIC FINITE ELEMENT ANALYSIS
OF ARBITRARY THIN SHELLS
Clough, R.W. and Wilson, E.L.
Computers and Struc. 1(1-2), 33-56
(Aug. 1971)

Refer to Abstract No. 72-10

The authors start with a discussion of the approximations caused by: (1) replacing the actual continuous shell surface by an assemblage of finite elements varying in complexity, ranging from a simple, flat triangular to more complex curved elements of linearly varying curvature; (2) the complexity of the shape function used; (3) interelement compatibility; and (4) basic shell theory where the shell is treated as a two-dimensional surface. They state that these approximations provide only a limited arbitrary shell surface, the criterion for selection of the complexity of the shape function to be used should be the computer time required to achieve the desired degree of accuracy, curved elements provide improved convergence and that three-dimensional elements can account for shear distortions without difficulty.

The factors affecting solution efficiency are taken to be dependent on the element properties and the inclusion of the degree of representation of the rotation about the normal to the shell surface. In discussing the effect of element properties, the authors compare the results obtained from three types of flat elements, two curved versions of the flat elements, and two types of three-dimensional solid elements when applied to the problem of a cylindrical shell supported at its circular ends by diaphragms and free along its straight edges. The conclusions reached are that although this single example can hardly be considered as conclusive evidence, it appears that curvature is not essential in a finite element, that the form of the assumed shape function is as important as the geometric assumption, and that the three-dimensional element with selective strain integration appears to offer great promise as a general analytical tool.

While the application of finite elements to flat structures is well established, the application of curved elements to shell structures is not well understood. In the reviewer's opinion the first contribution to such an understanding is the work of Cantin and Clough, Ref. 1, where a curved cylindrical shell element was developed to satisfy the requirement of rigid body displacement. In Ref. 2, an investigation was carried out to assess this element when applied to arches. The problem of a circular arch was chosen because: (1) it is the simplest such problem which introduces curvature and thus gives rise to the difficulty associated with need for rigid-body modes, and (2) exact analytical solutions to a number of problems can be readily obtained. Several problems were solved, for arches of different radius-to-thickness ratios, and subtending different angles; and curves were plotted showing convergence with increasing number of elements. As was expected, the Cantin and Clough element was superior to the simple polynomial shape function element, but, unexpectedly, the success of both elements (and also a "shallow shell" modification of Cantin and Clough's element) was strongly dependent on the proportions of the arch considered. Thus, while all the shape functions gave reasonable convergence for a thick (radius/thickness ratio 40) and moderately shallow (subtending 40) arch, none of the shape functions converged (for up to 36 elements) if the arch was thin (radius-to-thickness ratio 320) and deep (subtending 180 deg).

This result suggested that it was necessary to consider other shapefunctions if it was required to solve arches (and therefore cylindrical shells) of all proportions. This was done in Ref. 3, in which (1) the 48 x 48 shape function of Bogner, et al (Ref. 4) was applied to arches, and (2) a new shape function was developed for an arch element based on satisfying the condition that the circumferential strain and charge of curvature, rather than the displacement, should be simple independent functions of the coordinate axes. This new element was found to converge more rapidly than all the elements with which we compared it, whether we used it to calculate deflections or stress resultants. This element had additional advantages in that it required fewer degrees of freedom than the Bogner, et al, element and it included a simplified form of the terms which Cantin and Clough introduced to allow rigid body displacements of the element. The new shape function differed from all previous shape functions in that it contained terms coupled between the circumferential and radial displacements, not only to provide the rigid body displacements (as in Cantin and Clough's element) but also to provide deformation of the element.

In Ref. 5, the more important of the shape functions were compared to obtain natural frequencies of a ring vibrating in its plane. It was shown that the new shape converged more rapidly than all the others. In a recent paper, Wolf (Ref. 6)

used 99 straight beam elements to study the natural frequencies of circular arches, this results in an overall stiffness and mass matrixes of 300 x 300 in size before boundary conditions are applied. The computer time for eigensolutions for matrixes of such sizes is excessive. The information given in Ref. 5, particularly Fig. (5), which shows the convergence curves for a thin ring vibrating into six full-wave modes, indicates that if the new shape function is used it is only necessary to deal with matrixes of less than 20 x 20 rather than 300 x 300.

The work on arches was only of initial interest (except that it showed the failure of previously existing shape functions for deep thin arches and therefore shell), unless it could be shown that the method used for obtaining a satisfactory shape function could be applied to cylindrical shells also. This is now done in Ref. 7, where a 20 x 20 degree-of-freedom curved cylindrical shell element satisfying the conditions of rigid body displacement and constant strain is used. Several problems were analyzed including the pinched cylinder problem and roof type barrel vaults. The results are compared with Cantin and Clough's element, Ref. 8, Cantin's, Ref. 9, and other high-order polynomial shape functions for triangular elements and hybrid elements. The superiority of the new element is particularly marked when it is applied to thin deep shells and has the advantage of being simple in form. It is noted that previous authors solved for cylindrical shells of a radius-to-thickness ratio of between 50 and 100, whereas an element that converges satisfactorily for such shells may not do so if this ratio is increased sufficiently and deep shells are more often tested than shallow shells.

The reviewer's opinion is that much more research is needed into simple curved elements based on satisfying the requirement of rigid body displacement and independent strains rather than independent displacement. The reviewer awaits with interest an extension of Ref. 7 to a triangular double curved element.

The authors also give a formulation of the finite element method to dynamic problems and present several solutions, for linear and geometrically nonlinear thin shell problems. They conclude that constraint of the degree of freedom representing rotation about the normal shell is desirable for computational efficiency. If curved elements are used, this degree of freedom is automatically constrained as no transformation of axes at the nodes is required. This computational efficiency is partly dependent on the complexity of the element and partly on the number of degrees of freedom. The solution time parameter suggested in Ref. 9, should be used when comparing elements of the same complexity.

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A MEMBRANE ANALOGY TO AN ACOUSTIC DUCT
Hine, M.J. and Fahy, F.J.
J. Sound and Vib. 18(1), 1-7 (Sept. 8, 1971)

Refer to Abstract No. 71-1457

This paper arose from a broader study into the acoustically induced vibration of rods within a sound carrying duct. In particular, efforts were directed toward establishing the conditions under which gas cooled reactor fuel elements would respond to circulator noise transmitted into the fuel channels. The technique of the membrane analogy used in the paper was of assistance in facilitating study of the influence of neighboring rods as regards the modal behavior in a duct with such complex boundaries, and thereby presents a useful experimental tool for determining the preferred frequencies and cross-sectional modal patterns for sound frequencies in a duct.

An analysis shows that the velocity potential of modes (pressure patterns in a duct) are similar to the mode displacement patterns for a membrane as regards circular and diametral mode lines. Thus, since the cross-sectional mode patterns within a duct are similar to those of a membrane, it is assumed that for any given geometrical change in boundary imposed on the one case a corresponding effect should be observed in the other case for similar changes through the analogy.

Modal behavior within such complex ducts may be deduced by referring to the membrane which was useful in these tests up to a limiting number of modes of (four) modal diameters. It is possible for higher order modes that measurements may be more easily made using, for example, displacement transducers than in the equivalent acoustic duct.

It is reported that for inner boundaries over a range of eccentricities, the natural modal frequencies are unaltered from those for concentric boundaries; an observation supported by evidence from acoustic waveguides.

In certain cases angular locking of the diametrical mode lines is observed and by introducing certain constraints on the drum skin the angular shift in the mode pattern could be observed. However, such angular locking was not observed in analogous acoustic waveguides. Thus any analysis based upon this analogy for ducts of infinite extent must be used with appropriate care. Further, in order to calculate the response of duct walls or rods to the acoustic pressures, it is also necessary to know the longitudinal pressure distributions associated with each mode. In a problem with complex boundaries the uniqueness of the relationship between cross-sectional mode patterns and a particular longitudinal distribution may not be readily obtainable.

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VIBRATIONS AND WAVES IN LAMINATED ORTHOTROPIC CIRCULAR CYLINDERS
Nelson, R.B.; Dong, S.B.; and Kalra, R.D.
J. Sound and Vib. 18(3), 429-444 (Oct. 8, 1971)

Refer to Abstract No. 72-86

This paper presents a method for a free vibration analysis of an infinite circular cylinder consisting of an arbitrary number of elastic, cylindrically orthotropic layers. The analysis is based on the linear theory of anisotropic elasticity and uses the "assumed modes" technique (i.e., extended Ritz) for describing the displacement modes. Therefore, the method of analysis is straightforward and traditional.

The displacements are taken in the form of trigonometric functions in both the circumferential and axial variables, while their radial form is modeled by polynomial functions valid and continuous through each lamina. Thus, the cylinder is modeled radially as a collection of bonded finite elements. The discretized model allows a formulation of a typical algebraic eigenvalue problem which is solved numerically to obtain the frequencies and associated mode shapes and stresses.

Results are presented from studies of homogeneous, isotropic cylinders to demonstrate the validity of the approach. A limited investigation of layered orthotropic cylinders was performed to furnish some insight into their physical behavior. Because the method of analysis is well-known, the results of the study should be quite acceptable for studies of idealized cylinders.

Of particular interest was the reordering of the dominant effects in the vibrations of orthotropic bodies. For example, "thickness (radial) stretch" modes replaced the more usually expected shear modes in the lower end of the frequency spectrum. This effect is undoubtedly due to the combination of material characteristics in the particular problem studied.

The study represents a significant step in advancing our understanding of the mechanics of layered (i.e., composite) structures. This study should be followed by a carefully undertaken experimental investigation to establish the applicability of the theory to practical structures as, for example, filament-wound pressure vessels. Furthermore, an extension of the analysis to include prestress effects seems warranted.

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FILTER DESIGN FOR VIBRATION ISOLATION BETWEEN MULTIRESONANT STRUCTURES
Wang, W.M.
J. Sound and Vib. 16(3), 309-314
(June 8, 1971)

Refer to Abstract No. 71-1047

This paper describes a design for passive mechanical vibration isolation that has been developed from the electrical m-derived filter. Equivalent electrical circuits are used to show the probable behavior of such a filter, together with relevant mathematics and a design chart for the probable attenuation of a single mechanical filter.

The filter design obtained from the analysis is a modification of the familiar undamped vibration absorber. The author claims that his method permits the combination of many of these vibration absorbers to obtain a wide band of vibration isolation.

It is not clear from the paper how this effect is to be achieved and the paper also suffers from the lack of any attempt to consider how the ideas expressed can be put to practice. The author has not reported any attempt to build such a filter and measure its actual response.

The paper contains some ideas which ought to be of use to the designers of mechanical vibration isolators. The author describes a modification of driving point impedance that can lead to improved isolation and he demonstrates that his filter design is the only design possible with passive mechanical elements (omitting the simple spring). However, the paper in its present form will only be of use to a sophisticated vibration engineer. A layman will be unable to make use of the ideas hidden in this paper's abstract exposition.

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NATURAL VIBRATIONS OF THIN, FLAT-WALLED STRUCTURES WITH DIFFERENT BOUNDARY CONDITIONS
Cheung, M.S. and Cheung, Y.K.
J. Sound and Vib. 18(3), 325-337
(Oct. 8, 1971)

Refer to Abstract No. 72-9

A method is presented for calculating the natural frequencies and mode shapes for a variety of structures that can be represented by long flat thin finite strips. The technique is similar to a finite element analysis, except that the elements used are thin strips between two opposite edges of the structure. Four sets of boundary conditions are considered at the ends of the strips: (1) simply-supported on both ends; (2) simply-supported on one end and clamped on the other; (3) clamped on both ends; and (4) clamped on one end and free on the other. Arbitrary uniform boundary conditions are allowed on the other two edges of the structure. Displacement functions for each strip are assumed to be in the form

$$\sum_{m=1,2\ldots} \delta_m(x) \cdot_m(y),$$

where $\cdot_m(y)$ functions are characteristic beam functions satisfying the boundary conditions at the ends of the strips and $\delta_m(x)$ are polynomials. Thus the problem is reduced to a one-dimensional problem in the x direction, with lower order mass and stiffness matrixes than occur with conventional finite element analysis, resulting in smaller computer core requirements and calculation time.

An overall stiffness matrix, K, for the structure is derived from bending and in-plane strain energies for assumed deformations in each strip. Likewise the structural mass matrix, M, is derived from the kinetic energies associated with each strip. Finally, the natural frequencies and mode shapes are found from the eigenvalues and eigenvectors of the familiar equation

$$(K - \omega^2 M)\ S = 0.$$

Examples provided in this paper show the numerical results of applying this technique to three types of structure: (1) a flat panel with four stiffeners and a variety of edge conditions; (2) an I-beam; and (3) a folded roof structure. The stiffened panel is of particular interest since this type of structure, with simple supports along two edges, has also been studied through transfer matrix analysis (Ref. 1). In addition, other boundary conditions have been considered on similar structures analyzed with a more conventional finite element approach (Ref. 2). The reader should exercise caution when applying the strip technique to this type of structure, since the authors have not included torsional energy terms in the calculation for their stiffeners. It has been shown several times (Refs. 1 through 4) that both St. Venant torsion and warping effects due to nonuniform torsion can significantly alter resonant frequencies and mode shapes of specific geometries of this type. Therefore, this strip method should only be applied to structures in which the torsional stiffness of the stringers can be neglected, as might well be the case for the examples shown in this paper.

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MEASUREMENT OF THE ELASTICITY AND ULTRASOUND VELOCITIES IN STEEL
Date, E.H.F.; Atkins, M.; and Beaton, G.V.
Ultrasonics 9(4), 209-214 (Oct. 1971)

Refer to Abstract No. 72-169

The velocity of ultrasound in solid materials is determined by the elastic stiffness constants (or Young's modulus) and shear modulus. The elastic stiffness constants are not necessarily constants but do vary as a function of pressure and temperature, for example. Thus, in an inverse fashion the measurement at the velocity of ultrasound can also be regarded as a measurement of temperature. In an ultrasonic standing wave resonator, the resonance frequency is determined by the sound velocity. Since the resonance frequencies can usually be measured with great accuracy, the corresponding elastic moduli can easily be obtained from the shift in resonance frequency as a function of temperature.

Young's modulus can also be measured by static methods, but particularly at high-temperature plastic deformations and creep can produce erratic results. Dynamic ultrasonic methods avoid these error sources, since the direction of stress reverses before any creep can occur.

Date, Atkins and Beaton have measured Young's moduli in various steel samples up to 600°C simply by carefully exciting longitudinal and torsional resonances in a rod shaped specimen through electrostatic drive. The specimen is carefully supported in such a way that the mounting losses are minimized. By supplying electrostatic drive to the rod at a proper angle, the authors could selectively excite longitudinal and torsional vibrations and the Young's modulus and shear modulus could be deduced. The temperature range of the resonance method was limited to 600°C due to increased attenuation as the transformation range of some samples was approached and the electrostatic drive lacked the power to cause vibrations in the samples.

The authors do give an analysis of the accuracy of the resonance method but neglect to discuss the possible effect of the thermal expansion of the rods upon the resonance frequency.

To extend the temperature range, Date, Atkins and Beaton have used transit time measurements in the sample using the well-known pulse method. The ultrasonic transducers could be kept outside the furnace by placing the sample at the end of a long buffer rod while the sample could be heated up to 1000°C. The measured longitudinal and shear velocities can then be used to provide the elasticity parameters including Poisson's ratio through the well-known relationships.

The inherent disadvantage of using buffer rods is the possible waveguiding effects from diffraction spreading. Date, Atkins and Beaton have managed to minimize the confusing reflections from the sidewalls simply by roughening them with a thread.

The two mentioned methods have been used to measure a great number of various steel samples and the results have been plotted, like commercial mild steel, austenitic stainless steel, ferritic stainless steel (16 percent chromium) and a 10 percent carbon 1.5 percent chromium ball race steel.

The present investigation clearly shows the advantage of using ultrasonic waves as a convenient noninvasive probe in the evaluation of elastic properties of solid materials and should be of great interest to engineers working in this field.

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AN OPTIMUM SHOCK ISOLATOR
Mercer, C.A. and Rees, P.L.
J. Sound and Vib. 18(4), 511-520
(Oct. 22, 1971)

Refer to Abstract No. 72-66

A new shock isolator is proposed that utilizes a variable friction damper in parallel with a spring. For small deflections the spring dominates the force-deflection characteristics of the isolator, whereas for large deflections, such as encountered in many shock environments, the friction force increases as a function of the deflection up to some maximum value, resulting in the desirable constant force characteristic.

The response of a mathematical model of the isolator to several shock pulses measured onboard a ship was determined through use of a digital computer indicating substantial reductions in peak accelerations.

Even though such an isolator apparently has not been built, it is believed that the idea of a passive adaptive isolator has considerable merit. However, the authors leave a great many questions unanswered in this paper. First, no hint is given as to why this isolator is called an "optimum isolator." As a matter of fact, the isolator is not optimum, where "optimum" is defined as minimizing the maximum relative displacement between the isolated body and the structure for a given maximum allowable acceleration of the isolated body. For example, it can be shown that for many shock pulses the pure coulomb device is optimum, whereas any deviation from the constant force behavior will result in an isolator whose performance always deviates from optimum. Second, the authors call their device a "fully adaptive isolator", whereas only one parameter varies as a function of displacement and velocity. A fully adaptive isolator must also change its direction of motion as a function of the applied shock pulse.

Third, the schematic representation of the isolator, Fig. 5, does not indicate how the force-displacement history as shown in Fig. 6 can be obtained. In addition, the authors mentioned that one of the difficulties of a pure coulomb device is that it often will not return to its equilibrium position, yet judging from Fig. 6, the proposed isolator appears to suffer from the same difficulty even though it is implied that it does not.

Fourth, and most important, no comparative results are presented to indicate that this new isolator will perform any better than a simple linear spring, viscous damper isolator. Particularly for the forcing functions shown, it is believed that no significant advantage would be obtained. In one case, the results shown indicate a reduction of the peak acceleration from 380 to 0.75 g. Many other isolators may reduce the peak acceleration to approximately the same value, and for all practical purposes, these differences may not be significant.

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Meeting	Date 1972	Location	Contact
	APR.		
13th Structures, Structural Dynamics and Materials Conference, AIAA, ASME, SAE	10-12	San Antonio, Tex.	Meetings Manager, AIAA Hq.
3rd Annual Conference on Composite Materials Testing and Design, ASTM	10-14	San Antonio, Tex.	H. H. Hamilton, ASTM Hq.
Spring Meeting, IEEE, URSI-USNC	13-15	Washington, D.C	J. V. Evans, URSI-USNC Hq.
Diesel and Gas Engine Power Conference and Exhibition, ASME	16-20	St. Louis, Mo.	A. B. Conlin Jr., ASME Hq.
Spring Meeting, ASA	18-21	Buffalo, N.Y.	M. Flynn, EE Dept., Univ. Rochester, Rochester, N.Y. 14627
Instrument Maintenance Symposium, ISA	24-26	Pittsburgh, Pa.	V. J. Giardina, ISA Hq.
National Structural Engineering Meeting, ASCE	24-28	Cleveland, Ohio	Meeting Manager, ASCE Hq.
18th Annual Meeting and Equipment Exposition, IES	30-4	New York, N.Y.	Tech. Program Committee, IES Hq.
Joint Space Simulation Conference, IES, AIAA, ASTM	30-5	Los Angeles, Calif.	B. L. Petersen, IES Hq.
	MAY		
National Telemetering Conference, IEEE	1-5	Houston, Tex.	IEEE Hq.
27th Annual Technical Conference and Exhibit, ASQC	8-10	Washington, D.C.	R. W. Shearman, ASQC Hq.
Design Engineering Conference and Show, ASME	8-11	Chicago, Ill.	T. Ferdinand, ASME Hq.
Symposium on Noise and Vibration Control for Industrialist, SEE	10-12	Bath Univ. Tech., Bath, England	Secretariat, SEE Hq.
6th St. Louis Symposium on Composite Materials in Engineering Design, ONR, ARPA	11-12	St. Louis, Mo.	D. R. Notoa, Engr. Design Lab., Wash. Univ., Box 1185, St. Louis, Mo. 63130
Mid-Year Meeting, SAE	15-19	Chicago, Ill.	A. J. Favata, SAE Hq.
Spring Joint Computer Conference, AFIPS	16-18	Atlantic City, N.J.	H. G. Asmus, AFIPS Hq.
Power Instrumentation Symposium, ISA	22-24	Dallas, Tex.	A. A. Sprioto, Bechtel Corp., Box 58587, Los Angeles, Calif. 90058
National Automobile Meeting, SAE	22-26	Detroit, Mich.	A. J. Favata, SAE Hq.
Spring Meeting and Exposition, SESA	23-26	Cleveland, Ohio	B. E. Rossi, SESA Hq.
National Air Transportation Meeting and International Forum for Air Cargo, SAE, AIAA, ASME	31-2	Washington, D. C.	A. J. Favata, SAE Hq.
	JUNE		
Lubrication Symposium, ASME	5-8	Boston, Mass.	A. B. Conlin Jr., ASME Hq.
13th Joint Automatic Control Conference, AIAA AIChE, ASME, IEEE, ISA	12-14	Stanford Univ. Stanford, Calif.	D. B. DeFea, Stanford Univ., Stanford, Calif. 94305
Applied Mechanics Conference, ASME	26-28	Univ. Calif. La Jolla, Calif	A. B. Conlin Jr., ASME Hq.
	JULY		
National Transportation Engineering Conference, ASCE	17-21	Milwaukee, Wis.	Meetings Manager, ASCE Hq.
	AUG.		
National West Coast Meeting, SAE	21-24	San Francisco, Calif.	A. J. Favata, SAE Hq.
6th International Conference on Nonlinear Oscillations, Acad. Sci. USSR, Czech. Acad. Sci., German Acad. Sci., Polish Acad. Sci.	29-4	Poznań, Poland	Polish Acad. Sci., Inst. Fundamental Tech. Res., Organizing Committee of the 6th Intl. Conf. Nonlinear Oscillations, Warsaw, Swietokrzyska 21, Room 334, Poland
Applied Mechanics Western Conference, ASME	29-31	Honolulu, Hawaii	A. B. Conlin Jr., ASME Hq.
	SEPT.		
National Combined Farm Construction and Industrial Machinery and Powerplant Meeting, SAE	11-14	Milwaukee, Wis.	A. J. Favata, SAE Hq.
	OCT.		
National Aeronautic and Space Engineering and Manufacturing Meeting, SAE	2-6	San Diego, Calif.	A. J. Favata, SAE Hq.
International Conference on Water Control Engineering, INCE	4-6	Washington, D.C.	M. J. Crocker, R. W. Herrick Labs., School Mech. Engr., Purdue Univ., Lafayette, Ind. 47907
12 US Mechanics Conference, ASME	8-11	San Francisco, Calif.	A. B. Conlin Jr., ASME Hq.
Industrial and General Applications Group Annual Meeting, IEEE	9-12	Philadelphia, Pa.	J. A. Herrmann, ITE Circuit Breaker Co., 1900 Hamilton St., Philadelphia, Pa. 19130
Symposium for Gearing and Transmissions, IFToMM, ASME, AGMA	11-12	San Francisco, Calif.	A.L. Tucker, Mail Zone C-3, Solar Div., Int. Harvester Co., 2200 Pacific Hwy., San Diego, Calif. 92112
Annual and National Instrument Meeting, ASCE	30-30	Houston, Tex.	Meetings Manager, ASCE Hq.
Fall Meeting, SESA	17-20	Seattle, Wash.	B. E. Rossi, SESA Hq.

CALENDAR

Meeting	Date 1972	Location	Contact
15 Stapp Car Crash Conference, Wayne State Univ., Univ. Mich., SAE, Univ. Calif.	NOV. 8-10	Detroit, Mich.	A. J. Favata, SAE Hq.
Winter Annual Meeting, ASME	12-16	New York, N.Y.	A. B. Cardineau, ASME Hq.
Fall Joint Computer Conference, AFIPS	14-15	Las Vegas, Nev.	D. R. Crusen, AFIPS Hq.
Fall Meeting, ASA	27-1	Miami Beach, Fla.	M. Kronengold, Inst. Marine Sci., Richenbacher Causeway, Miami, Fla. 33149
75th Anniversary Meeting, ASTM	DEC. 3-5	New Orleans, La.	H. H. Hamilton, ASTM Hq.
43rd Shock and Vibration Symposium	5-7	Anaheim, Calif.	Shock and Vibration Information Center, Washington, D.C. 20390
Automotive Engineering Congress and Exposition, SAE	1973 JAN. 8-12	Detroit, Mich.	A. J. Favata, SAE Hq.
Dynamics Specialist Conference, AIAA	MAR. 19-20	Williamsburg, Va.	Meetings Manager, AIAA Hq.
14th Structures, Structural Dynamics and Materials Conference, AIAA, ASME, SAE	20-23	Williamsburg, Va.	Meetings Manager, AIAA Hq.
International Convention and Exhibit, IEEE	26-29	New York, N.Y.	J. M. Kinn, IEEE Hq.
Annual Structural Engineering Meeting, ASCE	APR. 9-13	San Francisco, Calif.	Meetings Manager, ASCE Hq.
Joint Railroad Technical Conference, IEEE, ASME	11-12	St. Louis, Mo.	IEEE Hq.
International Congress on Experimental Mechanics, SESA	MAY 13-18	Los Angeles, Calif.	S. E. Prest, SESA Hq.
National Automobile Meeting, SAE	14-18	Detroit, Mich.	A. J. Favata, SAE Hq.
Spring Joint Computer Conference, AFIPS	15-17	Atlantic City, N.J.	H. C. Asmus, AFIPS Hq.
14th Joint Automatic Control Conference, AIAA, AIChE, ASME, IEEE	JUNE 20-22	Ohio State Univ. Columbus, Ohio	H. R. Weed, Dept. EE, Ohio State Univ., Columbus, Ohio 43210
76th Annual Meeting and Exposition, ASTM	24-25	Philadelphia, Pa.	H. H. Hamilton, ASTM Hq.

ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS — American Federation of Information Processing Societies
210 Summit Ave., Montvale, N.J. 07645

AGMA — American Gear Manufacturers Association
1330 Mass. Ave., N.W., Washington, D.C.

AIAA — American Institute of Aeronautics and Astronautics
1290 Sixth Ave., New York, N.Y. 10019

AIChE — American Institute of Chemical Engineers
345 E. 47 St., New York, N.Y. 10017

ARPA — Advanced Research Projects Agency

ASA — Acoustical Society of America
335 E. 45 St., New York, N.Y. 10017

ASCE — American Society of Civil Engineers
345 E. 47 St., New York, N.Y. 10017

ASME — American Society of Mechanical Engineers
345 E. 47 St., New York, N.Y. 10017

ASNT — American Society for Nondestructive Testing
914 Chicago Ave., Evanston, Ill. 60202

ASQC — American Society for Quality Control
161 W. Wisconsin Ave. Milwaukee, Wis. 53203

ASTM — American Society for Testing and Materials
1916 Race St., Philadelphia Pa. 19103

IEEE — Institute of Electrical and Electronics Engineers
345 E. 47 St., New York, N.Y. 10017

IES — Institute Environmental Sciences
940 E. Northwest Highway, Mt. Prospect, Ill. 60056

IFToMM — International Federation for Theory of Machines and Mechanisms
US Council for TMM, c/o Univ. Mass., Dept. ME,
Amherst, Mass. 01002

INCE — Institute of Noise Control Engineering

ISA — Instrument Society of America
400 Stanwix St., Pittsburgh, Pa. 15222

ONR — Office of Naval Research
Code 400B4, Dept. Navy, Arlington, Va. 22217

SAE — Society of Automotive Engineers
3 Pennsylvania Plaza, New York, N.Y. 10001

SEE — Society of Environmental Engineers
68a Wigmore St., London W1H 9DL, England

SESA — Society for Experimental Stress Analysis
21 Bridge Sq., Westport Conn. 06880

SNAME — Society of Naval Architects and Marine Engineers
74 Trinity Pl., New York, N.Y. 10006

URSI-USNC — International Union of Radio Science - US National Committee
c/o MIT Lincoln Lab., Lexington, Mass. 02173

SVIC File No. _____

SUMMARY COVER SHEET
43rd SHOCK AND VIBRATION SYMPOSIUM
PACIFIC GROVE, CALIFORNIA, 5-7 DECEMBER 1972

NOTE 1. Five copies of each summary with title, author, and affiliation are to be attached.
2. Submission deadline is 31 July 1972. Earlier submissions will be appreciated.
3. Mail to: Shock and Vibration Information Center, Code 6020, Naval Research Laboratory, Washington, D. C. 20390
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